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RANDOM VIBRATION

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1. Introduction. Random vibration is vibration which results from an excitation which is not well represented by any simple function (sinusoid, step, etc.) or any simple combination of such functions but which is satisfactorily modeled by a stochastic process. It is perhaps not too much of an exaggeration to say that "All vibration is random vibration." Every vibration record contains "hash" at some level. Nevertheless, until recently, engineering vibration theory has been able to get along without including the consideration of random excitations.

Now in several fields simultaneously there has occurred a burst of activity in the application of random processes. The response of aircraft to buffeting from atmospheric turbulence and the response of ships to confused seas have been put on reasonably firm footing. Possibly the most dramatic problems have been posed by the development of large jet and rocket engines which produce spectacular amounts of random vibrational energy. The high level of random vibration in a jet plane or a missile provides a severe environment with respect to fatigue failure of structural members and with respect to malfunctions of sensitive equipment.

2. General theory. Probability and statistics have been incorporated in many areas of mechanics; e.g., kinetic theory (1), statistical mechanics (2), Brownian motion (3) and fluid turbulence (4). It is possible to consider that Brownian motion is a particular kind of random vibration. The first analysis of Brownian motion by Einstein (5) in 1905 involved only a mass particle subjected to damping and a fluctuating force, but this theory had been extended to vibratory systems such as strings and beams (6) by 1931. Modern random vibration owes a considerable debt to the theory of noise in communication devices (7), (8) and to the applications of this theory to control systems (9).

The central core of the theory is the notion of a stochastic process (10), (11). A stochastic process is used as a hypothetical model for an excitation in much the same way as a simple sinusoid is used. Both are usually fictitious oversimplifications of reality. When a single frequency component predominates, the simple sinusoid is a useful model. When there are so many components that it is not possible or convenient to identify them separately random process is a useful model. In dealing with stochastic processes averages are used in place of individual data. The most important of these averages are the correlation functions and their Fourier transforms, the power spectral densities.

The autocorrelation function $\psi(\tau)$ of a stationary random process $x(t)$ is defined as the average value of the product $x(t)\ x(t+\tau)$ where the average is to be taken across all the sample functions of the process. If the process is ergodic the ensemble average may be replaced by a time average for a single sample function as follows:

$$\psi(\tau) = \lim_{T\to\infty} \frac{1}{2T} \int_{-T}^{T} x(t)\,x(t+\tau)\,dt \qquad [1]$$

Note that the mean square value of x is given by $\psi(0)$. The power spectral density $S(f)$ may be defined as the Fourier transform of $\psi(\tau)$ with respect to $\omega = 2\pi f$.

$$S(f) = 2\int_{-\infty}^{\infty} \psi(\tau) e^{-i\omega\tau}\,d\tau \qquad [2]$$

The inverse transform gives the correlation function in terms of the spectral density

$$\psi(\tau) = \int_{0}^{\infty} S'(f) e^{i\omega\tau} df \qquad [3]$$

Because of the relation

$$\psi(0) = \int_{0}^{\infty} S(f)\,df \qquad [4]$$

which is obtained from [3] by setting $\tau = 0$, it follows that $S(f)$ can be interpreted as the contribution to the mean square of x (which is often proportional to power) per unit frequency at the frequency f. The concept of a correlation function was introduced by Taylor (12) in 1920 and the concept of power spectral density and the use of generalized harmonic analysis was put on a firm basis by Wiener (13) in 1930.

The importance of these averages resides in the fact that for a linear constant coefficient vibratory system it is possible

to obtain the response averages directly from a knowledge of the excitation averages (14). The first application of this to mechanical vibrations seems to be that of Lin (15), in 1943, who considered a single-degree-of-freedom vibratory system acted on by a force described only by its correlation function.

Stochastic processes are also described in terms of their associated probability distributions. The most important particular process is the Gaussian process which has the special property (16) that the response of a linear constant coefficient system to a Gaussian process is also a Gaussian process. A major contribution to the theory is the work of Rice (17) in which several important results concerning the statistics of the noise output of linear and nonlinear systems are derived. This work has been widely applied in studies of fatigue damage due to random vibration.

3. Sources of random excitation. Dynamic loading in almost all mechanical systems involves statistical aspects (18), (19), although in many cases the level of randomness is so low that it can be neglected. A common assumption is that the random process can be taken as stationary although some phenomena, e.g., earthquake motions (20), must be taken as nonstationary random processes. A graphic example of a random process is provided by the surface of the open sea. In 1952 Longuet-Higgins (21) showed that over a short interval ocean waves can be represented by a stationary narrow-band Gaussian process and that the distribution of wave heights is very nearly the Rayleigh distribution. A theory for the motions of ships in open seas was proposed by St. Denis and Pierson (22) in 1953 and has been extended (23) and partially verified experimentally (24).

Atmospheric turbulence presents a similar random excitation to airplanes. In 1952 Liepmann (25) gave the first complete analysis of the buffeting problem omitting the spatial distribution of the turbulence. This was soon extended (26), (27) to include the effect of the two-dimensional distribution of turbulence. See also (28), (29) and (30). Related measurements were reported in (31).

Large gas turbine jets and rocket motors generate intense levels of acoustic power. For an introduction to some of the problems of jet noise see the proceedings (32), (33) and (86) of three symposia on aircraft noise. In subsonic flight of missiles the main contribution to vibrational energy appears not to come directly through the structure from the engine but rather to be generated in the exhaust stream as an acoustic pressure variation which is transmitted through the atmosphere (34). This pressure fluctuation excites transverse vibrations of nearby structural panels which in turn transmit the vibration to adjoining spaces and connected structural members. A theoretical explanation of the mechanism of sound generation in the highly turbulent exhaust stream was given by Lighthill (35) in 1952. This theory predicts that acoustic pressures will be proportional to the fourth power of the jet velocity and that the acoustic power will be proportional to the eighth power of the jet velocity. Measurements have verified (36), (37) that there are indeed portions of the sound field in which this law is valid. The eighth power law cannot, however, apply to the total acoustic energy over a very wide range of velocities because at large velocities it predicts greater acoustical power than is available from the jet efflux. Recent experience tends to show that the acoustical power can never be greater than a very small fraction (say 1%) of the total jet power (38). Even so, the acoustical power may be in the megawatt range for a large rocket motor. Because of its turbulent origin this pressure variation is well represented as a random process. The distribution of power according to frequency usually shows a smooth variation over a broad band extending from a few cycles per second to well over 1000 cps. The theory of the generation of noise from turbulence has been extended and generalized by several authors (39), (40), (41), (42). In supersonic flight of missiles the main source of vibrational energy appears to be the pressure fluctuations in the boundary layer. The noise generated in a turbulent boundary layer and its transmission through the wall has been studied by Ribner (43), Kraichnan (44), and by Corcos and Liepmann (45).

4. Response of vibratory systems to random excitation. The response of a linear constant parameter vibratory system to a given excitation can be determined in either the time domain using the system's impulse response and the convolution integral or in the frequency domain using the system's frequency response and a Fourier transform of the excitation (46). When the excitation is not taken to be a fixed function but is considered as a random process these same tools can be used to obtain information about the response random process. In the important special case where the excitation is a stationary random process with known power spectral density $S_e(f)$ the response spectral density is simply

$$S_r(f) = S_e(f) \left| H(f) \right|^2 \qquad [5]$$

where $H(f)$ is the frequency response of the system (14). Because of Eq. [4] this means that in particular the mean square value of the response is readily available. The result in Eq. [5] is independent of the probability distributions characterizing the excitation process. While it is possible to obtain information regarding the probability distributions of the response in a general case (47), (84), very little has been done except in the case where the excitation is a Gaussian process. Here the response is also a Gaussian process with all its statistical information implicit in its power spectral density function. Expressions for the distribution of maxima and the average number of zero-crossings have been obtained (17), (48).

In dealing with continuous media there is the problem of the spatial distribution of the excitation as well as the temporal distribution. A general treatment of the propagation of correlation functions is given by Lyon (49) with application to vibrating string problems (50). Similar problems are solved by Powell (38) using the normal mode approach. Random vibration has been analyzed in beams (6), (51), (52), (53), in plates (51), (54) and in shells (34). The theory is in reasonably satisfactory condition within the restricted area of linear, constant-coefficient systems excited by stationary Gaussian processes. When any of these restrictions is relaxed there is a rapid deterioration in the state of knowledge.

Various aspects of *nonstationary* behavior have been studied. In Brownian motion distributions are obtained as a function of time from a fixed initial condition although the excitation is stationary. These may be considered to be the statistical analog of the starting transient. Nonstationary excitations have been treated by extending the concepts of correlation functions and spectral densities (55) and by selecting particular representations of nonstationary processes as combinations of deterministic functions and stationary random processes (56). In dealing with earthquake response Housner (57) introduced the idea of a response spectrum which is an envelope of the maximum responses of simple oscillators having all possible natural frequencies (58). A method for obtaining the mean square response of linear systems with variable coefficients subjected to random excitation was described by Duncan (59). Time-varying control systems subject to random excitations are discussed by Booton (60) and by Laning and Battin (61). Linear systems with time-varying parameters in which the variations of the parameters have had random components have been studied by Samuels and Eringen (85).

Investigations of random processes in *nonlinear* systems can be subdivided according to whether the response of the system: (a) is an instantaneous function of the excitation, or (b) depends on the entire past history of the excitation. Problems of type (a) have been studied in connection with noise in detectors and rectifiers in electronic communication

systems by Rice (17), Kac and Siegert (62) and others (63), (64). Extensions of these problems have been discussed by Wiener (65). Problems of type (b) are involved in vibratory systems which have nonlinear restoring forces or nonlinear damping forces. A general approach for the Brownian motion of systems with nonlinear elastic forces was outlined by Chandrasekar (66). The method of equivalent linearization or describing function technique has been applied to obtain the response to random excitation of a nonlinear control system (67). Caughey has obtained the response of a nonlinear vibrating string (68) and the Van der Pol oscillator (69) by this same method.

5. Failure due to random vibration. If the level is high enough, random vibration can be a very severe environment for structural members or sensitive equipment. When structural members undergo random vibration they are subjected to randomly varying stresses which can cause fatigue failure (70). Electronic equipment can malfunction for a variety of reasons. There may be fatigue failures of terminals or wiring. Relays may chatter or accidently open or close. Vacuum tubes may develop microphonics due to excess relative motion of the various electrodes. Hydraulic valves may chatter or leak, lines may burst. Gyroscopic instruments may generate excessive noise or may even tumble (71).

Except for a small number of exceptions (72), (73), fatigue data has been collected on non-random stress variations. A number of more or less rational damage accumulation theories have been proposed (70) which permit prediction of fatigue under random loading from this non-random data. The best known of these, the linear damage accumulation hypothesis, was suggested (independently) by Palmgren (74) and by Miner (75). Using this criterion and the statistical estimates of Rice (17), Miles (76) was able to predict the fatigue life of a resonant structural member subjected to random vibration. See also (77). For other types of failures there appears to be very little information available in the open literature. A start has been made (78), (79) on failures which are due to excess relative motion of compliant members, collision and bottoming.

6. Design and test. The problem of designing structures or equipment to operate in an environment of random vibration is complex and difficult. The available theory provides some rough guide lines for the designer. The general principles have been enunciated by Mains (71), (80). It would seem, however, that extensive test programs will be an important adjunct to the design effort for some time to come. The recent incorporation of random vibration specifications in vibration testing has caused a minor revolution (81). Processing and interpreting random vibration data is a complex and costly operation. An extensive treatment of the theoretical problems involved has been given by Blackman and Tukey (82). Problems peculiar to random vibration data processing are emphasized by Morrow (83). See also (28).

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Subject is divided into six chapters. First come interesting insights into the inner nature of continuity and discontinuity of func-

tions (the classical examples given by Bolzano and Weierstrass as well as the more modern constructions of Peano and Van der Waerden).

The second part is concerned with supplements to the theory of infinite series. Treated are estimate of coefficients and various methods of developing explicit and implicit functions into power series, Luzin's famous considerations on series converging everywhere in the interior and nowhere on the periphery of a unit circle. Attention is given to certain of Markof's results on doubly infinite series, to classical Euler transformation, etc.

Chapter three deals with the theory of extrema with additional conditions (among others, reduction of quadratic forms to principal axes) and chapter four is concerned with the transcendental character of the number.

The fifth chapter is devoted to various considerably profound facts from the field of trigonometric series. We expressly notice Fatou's and Perron's considerations on converging trigonometric series which do not coincide with the Fourier series of their sums, then the Gibbs' example on the nature of convergence of a Fourier series in the neighborhood of a discontinuity of belonging function, the singular behavior of Fourier series as studied by Lebesgue, du Bois-Reymond, Fejer and others.

The book concludes with attractive considerations relating to the classical Tchebychev theorem on expressibility of binomial integrals in terms of elementary functions.

V. Vodicka, Czechoslovakia

Book—5354. Bodewig, E., Matrix calculus, 2nd revised and enlarged ed., New York, Interscience Publishers, Inc., 1959, xi + 452 pp. $9.50.

For a review of the first edition see AMR **10** (1957), Rev. 952. Much new material has been added, including Lanczos' pq-algorithm and Rutishauser's LR-algorithm. The first edition was a worthy one, and the present one is even more so—a valuable addition to the applied worker's bookshelf. Y. L. Luke, USA

Book—5355. Zurmuhl, R., Matrixes, a treatment for engineers [Matrizen, eine Darstellung fur Ingenieure], 2nd ed., Berlin, Springer-Verlag, 1958, xv + 407 pp. DM 33.

This completely revised edition [AMR **4** (1951), Rev. 4361] has been rearranged and extended regarding increasing application of matrix calculus in engineering. Nevertheless, we find complete survey of pure-theory-results, expressed in a style amenable to the engineer. The visuability of matrix structures is improved by adoption of fertile concepts as classification of "normalisable" and "symmetrizable" matrixes and introduction of the system of "Hauptvektoren" for matrixes not similar to a diagonal representation. The applied mathematician finds an extended survey of methods for solving linear equations with error estimates. Reviewer misses some criteria of convergence of interation resulting from different definitions of a matrix norm, making use of the Weissinger Fixpoint Theorem. The chapter concerning eigenvalue problems has been enriched by methods of estimating lower and upper bounds. Nearly one third of the book is dedicated to applications, such as electrical networks, elastomechanical systems, transformation matrixes, static undetermined systems. Work is illustrated by 76 figures. K. Eggers, Germany

5356. Ostrowski, A. M., On the convergence of the Raleigh quotient iteration for the computation of the characteristic roots and vectors, Part I (in English), *Arch. Rational Mech. Anal.* **1,** 3, 233–241, May 1958.

Author uses iteration rules discussed earlier by S. H. Crandall, "Iterative procedures related to relaxation methods for eigenvalue problems," [*Proc. Roy. Soc. Lond.*, **207,** 416–423, 1951]. In the case of a real symmetric n by n matrix the convergence to the characteristic roots is shown to be cubic. The principal result is the asymptotic formula given concerning the convergence to the characteristic roots. J. Jones, Jr., USA

5357. Punga, V., A method of a matrix inversion, *Matrix Tensor Quart.* **9,** 2, 53–59, Dec. 1958.

Paper points out that computation involved in the simplex method of linear programming can be regarded as a method of matrix inversion. Reviewer comments that this is essentially the well-known Gauss-Jordan method [cf., e.g., K. S. Kunz, "Numerical analysis," McGraw-Hill, 1957, p. 221; AMR **11** (1958), Rev. 4330]. S. Moriguti, Japan

Book—5358. Dickson, L. E., Linear groups with an exposition of the Galois field theory, New York, Dover Publications, Inc., 1958, xvi + 312 pp. $1.95 (Paperbound).

Book is an unabridged and unaltered republication of the first edition, with a new introduction by Wilhelm Magnus, New York University. Ed.

Book—5359. Wiener, N., The Fourier integral and certain of its applications, New York, Dover Publications, Inc., 1959, xi + 201 pp. $1.50 (Paperbound).

Book is first American printing of the 1933 edition, and published by special arrangement with Cambridge University Press. Ed.

5360. Peretti, J., and Maradudin, A., The use of Fourier transforms for the study of singular points in the frequency spectrum of a crystal, AFOSR TN 59-21 (Univ. Maryland, Inst. Fluid Dynamics Appl. Math. TN BN-155; ASTIA AD 208 751), 8 pp., Nov. 1958.

A new method based on theorems relating to the asymptotic behavior of Fourier transforms is presented for determining the shape of vibrational frequency spectra in the immediate vicinity of their critical points. The method is illustrated by applying it to the determination of the shape of spectra due to analytic critical points for one-, two- and three-dimensional lattices.

From authors' summary

5361. LaSalle, J. P., and Lefschetz, S., Recent Soviet contributions to ordinary differential equations and nonlinear mechanics, AFOSR TN 59-308 (RIAS TR 59-3; ASTIA AD 213 092), 47 pp., Apr. 1959.

This report is an appraisal of recent Soviet contributions to differential equations and nonlinear mechanics. It contains a general appraisal of the significance and implications of Soviet research in this field. A somewhat nontechnical description is given of the major areas of research and of individual Soviet contributions. An appendix includes a more technical appraisal of the Soviet contributions. A mathematical abstract together with the names of the authors and exact references is given in this appendix for each of the major papers and books available to authors in 1958.

From authors' summary

5362. Power, G., and Jackson, H. L. W., Certain two-dimensional solutions to Poisson's equation, *Appl. Sci. Res.* (*B*) **7,** 4, 249–256, 1958.

A solution to Poisson's equation in two dimensions is presented, subject to reasonably general boundary conditions. A circular boundary is considered first; an indication is then given for the adaptation of the solution to other boundary shapes by means of conformal transformation.

From authors' summary by N. A. Weil, USA

5363. Butzer, P. L., Application of operational method of Jan Mikusinski to linear integral equations of the convolution type (in German), *Arch. Rational Mech. Anal.* **2,** 2, 114–128, Oct. 1958.

Use of Dirac delta function by physicists has spurred mathematicians to develop theories of "pseudofunctions" or "generalized

functions". One of the outgrowths of these efforts has been Mikusiński's book "Operational calculus", Warsaw 1957 [AMR **10** (1957), Rev. 3157]. Mikusiński's method is a generalization and simplification of the Heaviside method. It is easier to apply and reaches farther than the Laplace-transform approach.

Author of present paper first gives fundamentals of Mikusiński theory and then applies it to Volterra integral equations of the first and second kind, to systems of such equations, to integrodifferential equations, nonlinear integral equations and to singular integral equations, all of the convolution type.

H. Parkus, USA

Book—5364. Volterra, V., Theory of functionals and of integral and integrodifferential equations, New York, Dover Publications, Inc., 1959, 226 pp. $1.75 (Paperbound).

This new edition, first published in 1959, is an unabridged republication of the first English translation. Ed.

Book—5365. Peck, L. G., and Hazelwood, R. N., Finite queuing tables, (Publications in Operations Research Series No. 2), New York, John Wiley & Sons, Inc., 1958, xvi + 210 pp. $8.50.

This volume, the second in the ORSA series *Publications in Operations Research*, "... provides useful tables for the solution of a variety of queuing problems." There are a number of queue problems which can be defined by random arrival rates, exponential service times and finite populations. These tables refer to the case frequently referred to in the literature as "The Swedish machine problem," i.e. N machines attended by M operators, the machines being subject to random failure and the repair rates defined by an exponential distribution. The tables list the steady-state values of

D = probability that a unit which calls for service will be delayed
F = efficiency factor (the fraction of population not delayed) for fixed values of
N = population, M = number of service channels, and
X = service factor.

The values of M for a given N and X extended to $NX + 4\sigma = NX + 4\sqrt{NX(1-X)}$. The tables cover the following ranges

N: 4(1)26, 26(2)70, 70(5)170, 170(10)250;
X: 0.001(.001)0.026, 0.026(.002)9.070, 0.070(.005)0.170, 0.170(.010)0.340, 0.340(.020)0.600, 0.600(.050)0.950.

It is to be noted that the D calculated is not defined by Eq. [9] (page x) but by

$$D = \frac{\sum_{n=M}^{N} (N-n)\, P_n}{\sum_{n=0}^{N} (N-n)\, P_n}$$

which is the ratio of the mean number of customers "idle" when service facilities are fully occupied to the mean number of machines "idle". The preface is somewhat incomplete in defining terms for the cases tabulated.

The tables were obtained by calculating P_n to an accuracy of better than $N \cdot 10^{-11}$ on a Univac; the results were rounded to three significant figures for further calculations. The tables are prefaced by a number of illustrations of their utility, which extends beyond the Swedish machine problem. The utility of the tables is enhanced by the apparent insensitivity of the variables D and F to the arrival and service distributions for large values of N and small and moderate values of X. The tables should be included in the library of all O.R. organizations and service libraries. The individual OR worker may also find the volume a worthwhile element.

E. Koenigsberg, USA

5366. Cartwright, D. E., The prediction of a random function given simultaneous values of its first few derivatives, *J. Math. Phys.* **37,** 3, 229–245, Oct. 1958.

Author considers the stationary stochastic process $x_0(t) = \Sigma_n a_n \cos(\sigma_n t + \varepsilon_n)$ where a_n, Σ_n are to be considered as given while ε_n is uniformly distributed in $(0, 2\pi)$, $n = 1, 2\ldots$ It is assumed that $x_0(t)$ has derivatives of all order and that these derivatives can be obtained by differentiation, term by term, of the series for $x_0(t)$. The investigated problem is the prediction of future values of $x_0(t+\tau)$ from $x_0(t)$ and its derivatives at t. Author therefore considers the conditional distribution of $x_0(t'+\tau)$ given that (1) $x_0(t') = c_0$; (2) $x_0(t') = c_0$ and $d\,x_0(t')\,|\,dt = c_1$; (3) $x_0(t') = c_0$, $d\,x_0(t')\,|\,dt = c_1$, $d^2\,x_0(t')\,|\,dt^2 = c_2$. For these three cases the means and variances are calculated. Having obtained expressions for these quantities, author regards the mean of $x(t'+\tau)$ as the best predictable value, whereas the variance is considered as a measure for the inaccuracy of the prediction.

The influence of the shape of the autocorrelation function of the $x_0(t)$ process on the expressions for the means and variances is extensively studied; it is assumed that the energy spectra of the process is given by

$$m_0 (\sqrt{2\pi}\,\alpha\,\sigma_0)^{-1} \exp -\tfrac{1}{2}\left(\frac{\sigma-\bar{\sigma}}{at}\right)^2.$$

J. W. Cohen, Holland

5367. Tikhonov, V. I., When can a nonstationary random process be substituted for a stationary one (in Russian), *Zh. Tekh. Fiz.* **26,** 9, 2057–2059, Sept. 1956.

Author considers the nonstationary random process

$$\eta(t) = A\,\xi(t)\sin(\omega t + \varphi),$$

where $\xi(t)$ is a stationary random process, and compares the correlation function

$$K_\eta(t, \tau, \varphi) = A^2\,K_\xi(\tau)\sin(\omega t + \varphi)\sin(\omega t + \omega\tau + \varphi)$$

with the currently used expression

$$\tilde{K}_\eta(\tau) = A^2\,K_\xi(\tau)\,\frac{1}{2\pi}\int_0^{2\pi} \sin(\omega t + \varphi)\sin(\omega t + \omega\tau + \varphi)\,d\varphi =$$

$$\tfrac{1}{2}\,A^2\,K_\xi(\tau)\ \ \omega,\ \omega\,\tau,$$

where $K_\xi(\tau) = \overline{\xi(t)\,\xi(t+\tau)}$.

On a simple example of an RC circuit, where the deviations of the pointer of the voltmeter are characterized by a standard deviation of σ_φ, the difference between the two definitions of the correlation function is demonstrated and the conditions determined under which it is possible to replace the function $K_\eta(t, \tau, \varphi)$ by the expression $\tilde{K}_\eta(\tau)$.

Agnes H. Zaludova, Czechoslovakia

Computing Methods and Computers

(See Revs. 5355, 5356, 5357, 5362, 5370, 5455, 5819)

Analogies

(See also Revs. 5683, 5760)

5368. Fok, T. D. Y., and Au, T., On the solution of rigid frames by the column analogy, *Proc. Amer. Soc. Civ. Engrs.* **85,** ST 1 (*J. Struct. Div.*), Pap. 1914, 103–112, Jan. 1959.

Paper deals with the column analogy for rigid frames in which the method of virtual work is applied to prove the validity of the column analogy for the analysis of single-span rigid frames.

Reviewer believes that the paper is not of real importance, because it proves the correctness of expressions which are already well known and established (see page 112, 4th paragraph of the paper). J. G. Bouwkamp, USA

5369. Yamauchi, T., The experimental analysis for rigid frame structure by an analogous circuit consisting of resistors (in Japanese), *Trans. Japan Soc. Civ. Engrs.* no. 60, 30–36, Jan. 1959.

Author shows the method of experimental analysis for rigid frame structures. The circuit element corresponding to a member consists of three resistors only, and combines to T-shape. Expenses for the circuits are very small, the experiments are so simple, and results are in good accuracy. Problems without side sway are taken as examples. From author's summary

Courtesy, Editorial Committee of the Japan Society of Civil Engineers

5370. Draper, C. S., and Finston, M., High-accuracy mechanical integration by shear in viscous liquids, *Proc. Nat. Acad. Sci., Wash.* **45,** 4, 528–549, Apr. 1959.

The principle of integration based on applying the integrand as a torque to be resisted by viscous shear of a thin fluid film, and measuring the motion of the torque-receiving member, is described. This principle has been applied to rate-integrating gyros, but the possibility of other applications is mentioned though not pursued in the paper. A simple time lag, typically of the order of one millisecond, results from the inertia of the torque-receiving member. Most significant part of paper is devoted to analysis of further lags due to flow phenomena in fluid film. It is shown that this can be held to the order of microseconds.

Analysis makes use of Professor Draper's "self-defining" system of symbols, which, in reviewer's opinion, adds to any difficulties in following the exposition, and negates the valuable "shorthand" quality of mathematics—be this said without derogation to the admiration felt for Professor Draper's pioneer work.

R. Hadekel, England

Kinematics, Rigid Dynamics and Oscillations

(See also Revs. 5361, 5537, 5538, 5729, 5786, 5843)

Book—5371. Webster, A. G., The dynamics of particles and of rigid, elastic, and fluid bodies: Lectures on mathematical physics, 2nd ed., New York, Dover Publications, Inc., 1959, xi + 588 pp. $2.35 (Paperbound).

This new printing is an unabridged and unaltered republication of the second edition. Ed.

5372. Shuvayov, N. A., The equation of motion of the mass center of a system of points of variable mass (for the general case) (in Russian), *Ucb. Zap. Gorkovsk. In-ta* no. 28, 56–69, 1955; *Ref. Zh. Mekh.* no. 2, 1958, Rev. 1539.

Equations of motion are set up for the mass center of a system on the assumption that the mass of the system changes by the simultaneous addition and removal of particles, without consideration of their relative motion. The equations of motion of the mass center of the system are derived, both for an absolute system of counting and for a system with arbitrarily moving coordinate axes. Certain laws of the emission of particles are examined, for which the equations of motion of the mass center of the system assume a simpler form. A. I. Zenkin

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

5373. Savin, G. N., Some dynamic problems of non-elastic thread of variable length (in English), 9th Congrès Intern. Mécan. Appl., Univ. Bruxelles, 1957; **7,** 527–536.

Author formulates the problem of determining the dynamic tension force in a thread which is attached to a weight at its lower end and is wound at its upper end around a drum which is rotating at a prescribed velocity. The thread is assumed to be either of the viscoelastic type or with internal friction which can be expressed as an imaginary part of a complex stiffness. Author solves the problem approximately by taking the first two terms of the displacement function. He obtains several criteria regarding the effects of the various nonelastic parameters on the variation of the tension force in the thread and the change in amplitude of vibration of the suspended weight. T. H. H. Pian, USA

5374. Jeffreys, H., The simple pendulum under periodic disturbance, *Quart. J. Mech. Appl. Math.* **12,** 1, 124–128, Feb. 1959.

The motion of a pendulum with a periodic disturbance is examined. When higher powers of the displacement are retained there may be one or three periodic solutions according to the amplitude and period of the disturbing force. The elementary solution far from resonance corresponds to two different branches of the general solution, one of which ceases to exist when the resonance is sufficiently close.

From author's summary by H. D. Block, USA

5375. Wintner, A., A stability criterion for quasi-harmonic vibrations, *Quart. Appl. Math.* **16,** 4, 423–426 (Notes), Jan. 1959.

It is shown that if the coefficient function of the oscillator

$$x'' + \omega^2(t)x = 0$$

does not vanish identically and is of period π, then all solutions stay bounded as $|t| \to \infty$, whenever

$$\frac{1}{\pi}\int_0^{\pi} \omega^2(t)\,dt < Q(1-\theta^2)^{1/2},$$

where $Q = 0.8043\ldots\ldots$, and θ is the characteristic of $\omega(t)$ defined by

$$\theta = (M-m)/(M+m),$$

where

$$m = \min_{0 \leqq t \leqq \pi} \omega^2(t), \qquad M = \max_{0 \geqq t \leqq \pi} \omega^2(t).$$

G. Power, England

5376. Pol'skii, N. I., The essential and sufficient conditions for the convergence of generalization of Galerkin's method (in Russian), *Nauch. Zap. Zhitomirsk. Derzh. Ped. In-ta, Ser. Fiz. Matem.* **3,** 107–111, 1957; *Ref. Zh. Mekh.* no. 4, 1958, Rev. 4388.

It is shown that the sufficient condition found by the author in his dissertation "Convergence of approximate methods of the Galerkin type" [Kievskii universitat, 1950] for the convergence of the method by Galerkin-Pavlov also has to be deemed an essential condition. N. A. Kil'chevskii

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

5377. Osinski, Z., The influence of nonlinear characteristic of internal friction damping on forced vibration (in Polish), *Rozprawy Inz.* **7,** 1, 25–37, 1959.

A system with one degree of freedom and linear elastic characteristics stands under the action of a sinusoidal external force. Author examines the influence of the nonlinear damping $\alpha x + \beta x^3$ with a small coefficient β on the forced vibrations of the systems.

Denoting by D, E, N and q the vibration amplitude, the dispersed energy, the mean power and the amplitude of external force, respectively, it is known that, in the case of a linear damping, the ratios D/q, E/q^2 and N/q^2 do not depend upon q. Using the small parameter method, author finds that, in the case of nonlinear damping, the above ratios are functions of q. This dependence is examined in detail for the range of basic resonance.

The paper is to be considered as a welcome contribution to the theory of nonlinear vibrations.

V. Vodicka, Czechoslovakia

5378. Rabinovich, I. M., A geometrical presentation of the movement of an elastic system with one degree of freedom taking into account the fading effect (in Russian), Investigations in the theory of constructions, no. 6, Moscow, Gos. Izd-vo Lit. po Str.-vu i Arkhitekt., 1954, 39–44; *Ref. Zh. Mekh.* no. 4, 1958, Rev. 4507.

Author of this paper previously proposed a geometrical diagram giving a picture of all the characteristics of the movement of an elastic system with one step of freedom during the action of an arbitrary exciting force [Vestn. Voenno Inzh. Akad., no. 20, 1937]. In the present paper the method is extended to cover the case of the action of forces of viscous resistance. Another variant of the generalized method for the above case is given by V. I. Gofman [Investigations in the theory of constructions, no. 7, Moscow, Gos. Izd-vo Lit. po Str-vu i Arkhitekt., 1957].

Ya. G. Panovko

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

5379. Arnold, F. R., A derivation and application of the second Ritz method to the solution of nonlinear problems of multi-degree of freedom dynamical systems (in English), 9th Congrès Intern. Mécan. Appl., Univ. Bruxelles, 1957; **7**, 319–332.

Subject method is similar to Galerkin's method, which is widely used in the theory of elasticity. Confining the application of the method to the search for approximate periodic solutions, author derives the conditions for determining the unknown coefficients in the assumed solutions from Hamilton's principle. Using the concept of Euler equations, the conditions were made depending on equations of motion instead of Lagrangian function. To accomplish this for a multi-degree-of-freedom dynamical system, author points out that the assumed solution for each coordinate must contain the same number and kind of coordinate functions. Results from application to finding steady-state response of two-mass systems, with hardening main spring and hardening or softening coupling spring, to harmonic disturbance at the main mass are presented. Although single-term approximation was used in application, application to investigating sub- and superharmonic behavior is mentioned.

T. T. Chang, USA

5380. Filekin, V. P., Determination by oscillogram readings of resistance forces of nonlinear damping vibrations of an elastic system (in Russian), *Trudl Kuibyshevsk. Aviats. In-ta* no. 3, 239–245, 1957; *Ref. Zh. Mekh.* no. 3, 1958, Rev. 3210.

The problem is investigated of finding the form of the nonlinear relation between the force of resistance and the velocity during vibration of heterogeneous rods and plates. It is shown that the problem is solved on the basis of analysis of oscillograms of the damping vibrations of the sample under test, by means of the application of the asymptotic methods of nonlinear mechanics. A concrete example of the calculations is given. The conditions for smallness of the small parameter, on the degree of which the resolution is effected, are not determined in the paper.

G. V. Savinov

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

5381. Polyak, A. Ya., Instruments for torque measurements on the shafting of tractors and agricultural machines (in Russian), *Sb. Trudov Pozemledelcheskoy Mekhanike*, Moscow, Selkhozgiz., 1954, **2**, 242–259; *Ref. Zh. Mekh.* no. 2, 1958, Rev. 1605.

The requirements are determined which are to be applied to a torque-measuring instrument. Diagrams of such appliances are constructed and a table is given illustrating the methods of measuring torsional moments (torques). A mechanical appliance developed by the author is described, in which the torsional moment or peripheral force is mechanically transmitted to a connecting rod acting along the axis of the shaft. Three variants of the instrument have been developed: (1) for measuring moments transmitted by sheaves or sprockets arranged on the end of the shaft; (2) measuring with any arrangement of sheaves or sprockets, and with shafts in line; and (3) for measuring a torque transmitted between coaxially working shafts. The instrument is statically calibrated. A calibration curve is appended. The magnitude of the error does not exceed $\pm$ 2%. Frictional losses are not more than 0.5%. Instruments have been constructed for measuring torques up to 1000 kgm.

N. P. Raevskii

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

Instrumentation and Automatic Control

(See also Revs. 5370, 5688, 5786, 5790)

5382. Duthie, R. L., Feed forward can improve feedback controls, *Control Engng.* **6**, 5, 136–140, May 1959.

The "feed-forward" technique for improving servo accuracy without affecting stability is described. In systems where the error is a function of the input, a signal is derived from the input which reduces the error, improving system accuracy without increase of loop gain. Author describes some practical difficulties in developing a feed-forward unit which compensates zero-velocity-error position servos. Described is an "Acceleration Compensation Unit" which has been "widely and successfully applied to all-electric position servos and to those employing hydraulic drives."

Reviewer believes that this article is an interesting and valuable discussion of the feed-forward technique and its advantages.

V. Chobotov, USA

5383. Fraenz, K., and Herschel, R., A periodic followup control criteria (in German), *Regelungstech.* **6**, 9, 319–324, Sept. 1958.

In order to establish aperiodicity in a system with an amplification factor of given value, authors discuss two typical examples. The minimum value of the ratio between the greatest and the smallest time-constant is calculated. Tshebychev polynomial theory has been applied without, however, direct reference to this valuable work. Similar results can be obtained by the judicious application of the Nyquist stability criteria. Nine references, not quite commensurate with the depth of the problem, are given.

S. J. Zand, USA

5384. Tsypkin, Ya. Z., Linkages between the spectra of amplitudinally-modulated succession of impulses and its envelope (in

Russian), *Trudi Vses. Zaochn. Energ. In-ta* no. 7, 107–114, 1957; *Ref. Zh. Mekh.* no. 3, 1958, Rev. 2621.

Author defines, through $f^*(t)$, the modulated succession of impulses, following each other over an interval of time T_0 with a repetition frequency of $\omega_0 = 2\pi/T_0$, through $f(t)$, their envelope with which $f^*(t)$ coincides in discrete moments of time $t = nT_0$. If $F(j\omega)$ is the spectrum of $f(t)$ and the spectrum of $f^*(t)$ is determined on the basis of physical concepts through

$$F^*(j\omega) = \sum_{n=0}^{\infty} e^{-j\omega nT_0} f(nT_0)$$

then the linkage between the spectrum of the amplitudinally-modulated succession of impulses and the spectrum of the envelope will have the form

$$F^*(j\omega) = \frac{\omega_0}{2\pi} \sum_{m=-\infty}^{\infty} F[j(\omega - m\omega_0)]$$

An examination is made of the expression for the chain reaction during the envelope action through the chain reaction during impulse activity of the unit area and it is stated that the transmission of a continuous signal can be replaced by the transmission of a modulated succession of impulses with a repetition frequency of ω_0. For the particular case when the chain is an ideal filter with a frequency for the section $\omega_s = \omega_0/2$, an expression is obtained for $f(t)$ through its discrete values for $t = nT_0$.

V. S. Lyukshin

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

5385. Uderman, E. G., Dynamics of the linear following gear of systems of automatic induction (in Russian), Avtorefer. Diss. Dokt. Tekhn. Nauk Mosk. Energ. In-ta, Moscow, 1957; *Ref. Zh. Mekh.* no. 11, 1957, Rev. 12441.

5386. Bicknell, J., Larrabee, E. E., Seamans, R. C., Jr., and Whitaker, H. P., Automatic control of aircraft (in English), C. R. Journées Internationales de Sciences Aéronautiques, Paris, May 27–29, 1957; Paris, ONERA, Part I, 95–117.

5387. Horn, H., Practical investigation of the diminishing causes of wear in rocking-lever operated valve controls (in German), *Maschinenbautechnik* **6**, 5, 270–276, May 1957.

5388. Merkin, D. R., Influence of gyroscopic forces on the motion of an unconservative system (in Russian), *Uch. Zap. Leningr. Gos. Ped. In-ta* **103**, 107–125, 1955; *Ref. Zh. Mekh.* no. 3, 1958, Rev. 2598.

Investigations are made of material systems, the equations of disturbed motion of which can be brought to the form of

$$\ddot{q}_k + b_k \dot{q}_k + \sum_{j=1}^{n} [g_{kj} \dot{q}_j + (c_{kj} + e_{kj}) q_j] = 0 \qquad [1]$$

where

$$g_{kj} = -g_{jk}, \qquad c_{kj} = c_{jk}, \qquad e_{kj} = -e_{jk}$$

and the corresponding forces which are essentially gyroscopic, potential or unconservative (the last the author calls the forces of radial correction). A study is made for such a system of the conditions of asymptotic stability, which are formulated analogously with the classical theorems of Thomson and Tate on gyroscopic stabilization. It was shown that if the gyroscopes entering into the composition of the investigated system possess significant kinetic moment, then to obtain adequate conditions of asymptotic stability, it is possible to introduce limitations with determined, very weak conditions, by means of the analysis of Gurvits' inequality for two characteristic polynomes of degree $n/2$, one of which corresponds to the initial system of equations without positional terms, while the other–to the same system of equations with discarded metational terms (to the simplified system). It is shown that the solution of this simplified system appears to be acceptable, that is close to the solution of the initial system of the order of twice as large, provided only that the kinetic moments of the gyroscopes are sufficiently large.

L. A. Rozenberg

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

5389. Butler, R., A theoretical analysis of the response of a loaded hydraulic relay, Instn. Mech. Engrs., Prepr., 29 pp., 1958.

Problem concerns a detailed and exhaustive analysis of hydraulic power member, which is of basic utility in automatic control. Treatment is novel in that the analysis includes the important nonlinear effects present in such a device. Approach is to develop complete differential equations describing the device and to solve the resulting nonlinear equations by both analytical and numerical methods including a phase-plane treatment.

Consideration is given to the response to a step, ramp, sinusoid and arbitrary input. Author treats feedback around the relay and establishes parameter limits for cavitation-free operation. Consideration is given to the effects of overlap in valve, cavitation, compressibility, leakage, and nonlinear friction.

Paper is thorough, complete and of high quality.

L. A. Gould, USA

5390. Merkin, D. R., Motion of a gyroscopic system in equilibrium (in Russian), *Uch. Zap. Leningrad Gos. Ped. In-ta* **103**, 127–137, 1955; *Ref. Zh. Mekh.* no. 4, 1958, Rev. 3674.

An investigation is made of the motion of the axis of a gyroscope in free equilibrium relative to the earth, when the point of rest is in arbitrary motion on the earth's surface. On the assumption that the time spent on the observations is not so long as to allow the appearance of frictional influence in the suspension, it is shown that the coordinates of the gyroscope's axis, presented as functions of time, can be calculated either as emanating from geometrical transformations, or by recourse to the so-called simplified equation of motion, which can be obtained from the linear portion of the corresponding Ravs' function.

L. A. Rozenberg

Courtesy Referativnyi Zhurnal, USSR
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Elasticity

(See also Revs. 5407, 5413, 5415, 5421, 5425, 5432, 5454, 5469, 5477, 5485, 5570, 5592)

5391. Duffin, R. J., and Noll, W., On exterior boundary value problems in linear elasticity (in English), *Arch. Rational Mech. Anal.* **2**, 2, 191–196, Oct. 1958.

Authors adapt previous results by Finn and Noll [*Arch. Rational Mech. Anal.* **1**, p. 97, 1957] concerning uniqueness of Stokes flow to analogous elastic problems, and show that for an infinite elastic medium with displacements prescribed on internal boundaries, there is at most one displacement solution which tends uniformly to zero at infinity. Some two-dimensional results, including problem of transverse deflection of infinite thin plate, are also considered.

C. E. Pearson, USA

5392. Predeleanu, M., Translational function for axially symmetric problem of dynamics of elastic bodies (in German), *ZAMM* **38**, 9/10, 402–405, Sept./Oct. 1958.

Author considers the differential equation for the elastodynamic displacement vector and explains the methods of solution by Clebsch, Duhem, Moisil, Dacovache, Galerkin, Noll, Sobrero, Teodorescu, Krytkow and Boggio. The different representations of the axially symmetrical displacement vector at general nonstationary conditions are given in cylindrical coordinates.

H. Neuber, Germany

5393. Miyao, K., Stresses in a circular disk with an eccentric circular hole under radial forces, *Bull. JSME* **1,** 3, 195–198, Aug. 1958.

Two-dimensional elastic stresses in a circular disk with an eccentric circular hole, which is subjected to two concentrated radial forces, one on the outer periphery, the other at the center of the disk, are analyzed using bipolar coordinates and Jeffery's general solution for this kind of problem. Expressions of principal stresses along the inner and outer boundaries are derived, but they should be put in more compact and convenient forms for numerical calculation. Some numerical values of these principal stress distributions are calculated and shown in graphs.

T. Udoguchi, USA

5394. Bychawski, Z., and Piszczek, K., Pseudo-plane state of shrinkage distortion in a non-homogeneous circular cylinder (in English), *Arch. Mech. Stos.* **10,** 2, 211–232, 1958.

The process of concrete shrinkage does not take place simultaneously and uniformly at every point of an element. It is more intense in external layers having better contact with the ambient medium. The conditions of the shrinkage process correspond therefore to a certain type of nonhomogeneity of the medium.

Using experimental results, the state of shrinkage distortion, i.e. the state of strain caused by shrinkage, can be determined by equations in function of time and of physical parameters. Shrinkage distortion causes a time-variable state of elastic deformation in a concrete element. The total strain is the sum of elastic strain and distortion. The elastic nonhomogeneity of concrete is characterized by point- and time-variable Young's modulus of elasticity, whereas Poisson's ratio is assumed to be constant, since its changes are not essential.

For a nonhomogeneous concrete cylinder assumed to be sufficiently long in relation to the diameter, the state of strain is pseudo-plane and the shrinkage problem is reduced to the solution of a unique differential equation. Furthermore, the solution is given for a concrete cylinder containing a coaxial steel cylinder of smaller diameter representing a prestressing reinforcement. By comparison with numerical examples, very interesting results are found.

However, as authors emphasize, the theoretical model of this paper may constitute only a basis for a rough approximation and is to be supplemented by consideration of the plastic properties of concrete, in particular of the creep problem, which will be the object of another paper and which will change considerably the image obtained on the basis of the model of this paper.

E. Seydel, Germany

5395. Raer, G. A., Calculations for the strength of the blades of the wheel of a centrifugal ventilator (in Russian), *Energomashinostroenie* no. 9, 6–11, 1956; *Ref. Zh. Mekh.* no. 4, 1958, Rev. 4775.

The blade of a centrifugal ventilator, extended in the direction of the axis of rotation and representing in itself an unfastened long cylindrical shell, is examined as a thin-walled tube with a round profile in transverse section, which is connected by rivets at its ends to the basal and covering disks and is loaded with a distributed load—the centrifugal forces. The stresses in the blade, specified by the disk displacements and the aerodynamical forces, combined with the small rigidity of the blade and the relatively high number of revolutions of the ventilator ($n = 2500 - 3000$ revs/min) are taken to be of insignificant size. It is assumed that the supporting sections of the blade move freely round the principal central axes, but are prevented by fastenings from rotating round the longitudinal axis of the blade.

A. D. Kovalenko

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

5396. Seth, B. R., Finite bending of a plate into a spherical shell (in English), *ZAMM* **37,** 9/10, 393–398, Sept./Oct. 1957.

Author applies finite deformation theory to the bending of a circular plate into a spherical shell. Assuming usual linear stress strain law, he finds form of displacements which satisfy stress equations of equilibrium. The plate is assumed free of surface tractions and author evaluates forces and couples applied to the edge which are necessary to hold plate in spherical shape.

C. N. de Silva, USA

5397. Heller, S. R., Jr., Brock, J. S., and Bart, R., The stresses around a rectangular opening with rounded corners in a uniformly loaded plate, Proc. Third U. S. Nat. Congr. Appl. Mech., June 1958; Amer. Soc. Mech. Engrs., 1958, 357–368.

Title problem was solved by means of the complex variable method. Mapping function was obtained from a Schwarz-Christoffel integral, with the coefficients in the final approximate polynomial form determined in such a way as to make the boundary of the opening pass through a given set of points.

Y.-Y. Yu, USA

5398. Herrmann, G., On a complementary energy principle in linear thermoelasticity, *J. Aero/Space Sci.* **25,** 10, p. 660 (Reader's Forum), Oct. 1958.

A variational principle for linear thermoelasticity, corresponding to Castigliano's theorem of classical linear elasticity, is established. The proof of the principle is based on Biot's formulation of the equations of thermoelasticity which include the effect of entropy displacement. Author's principle constitutes a counterpart of the variational principle established by Biot for the thermoelastic linear case. Author promises that a less restricted proof of the present principle will be given in the future and that a more general variational principle for thermoelasticity will be formulated to correspond to Reissner's variational principle for both stresses and displacements in classical elasticity.

G. A. Zizicas, USA

5399. Lompriere, B. M., Thermal stresses in a box structure, *Coll. Aero. Cranfield Note* 84, 10 pp. + 4 figs., July 1958.

Author develops a method for determining the thermal stresses in a box-type wing structure resulting from the kinetic heating of the surfaces of the box-like structure. This structure is intended to simulate a multiweb aircraft wing structure in which the skin is uniformly heated thereby causing a parabolic temperature distribution in the web. The method is applied for the case where the moduli of elasticity of the web and skin are equal. The analytical results are compared with unpublished experiments previously carried out by P. Calkin. The correlation between experiment and theory is rather poor, as pointed out by the author. Causes for this discrepancy might be the variation of the test temperature distribution in the web from parabolic, inaccuracy arising from the computational need for using only one unknown term in the minimum energy calculations, or experimental difficulties in measuring thermal strains or temperature distributions. Author demonstrates the sensitivity of the axial stress distribution to the length of a finite box structure. The lateral stress variation is not shown.

A. L. Ross, USA

5400. Deresiewicz, H., Solution of the equations of thermoelasticity, Proc. Third U. S. Nat. Congr. Appl. Mech., June 1958; Amer. Soc. Mech. Engrs., 1958, 287–291.

Author obtains and examines several particular solutions of the coupled field equations appropriate to a homogeneous and isotropic solid within the linear theory of thermoelasticity. These solutions are deduced on the basis of a general solution of the equations just referred to, which, in turn, is derived with the aid of a Helmholtz resolution of the displacement field. [The solution thus arrived at is a generalization of Lamé's solution of the isothermal equations of motion in terms of a scalar and vector potential. The completeness of the present solution may be inferred from Duhem's (Mém. Soc. Sci., Bordeaux, Ser. 5, Vol. 3, 1898) completeness proof for Lame's solution.] The particular problems studied concern (a) plane waves of dilatation in an unbounded solid; (b) the longitudinal motion of a circular cylinder; (c) the thickness-stretch motion of an infinite slab. Problem (a) had been treated less directly by the same author in a previous publication [*J. Acoust. Soc. Amer.* **29**, 2, 204–209, 1957; AMR **10** (1957), Rev. 2441]. The same problem was also investigated independently in a more recent paper by Chadwick and Sneddon [*J. Mech. Phys. Solids* **6**, 3, 223–230, 1958; AMR **12** (1959), Rev. 2883]. In all three problems mentioned, the corrections due to the presence of the thermoelastic coupling term are shown to be quantitatively insignificant from an engineering point of view. E. Sternberg, USA

5401. Yarema, S. Ya., Analysis of the thermal stresses in the cylindrical part of a boiler shell (in Russian), *Nauchn. Zap. In-ta Mashinoved. i Avtomatiki, Akad. Nauk USSR* **6**, 60–74, 1957; *Ref. Zh. Mekh.* no. 4, 1958, Rev. 4783.

The problem is investigated of the thermal stresses in the cylindrical wall of a boiler shell, the temperature of which varies in circular fashion following the principle

$$t(\vartheta) = t_0 + \sum_{n=1}^{m} t_n \cos n\vartheta$$

It is established, on the basis of a solution given by V. V. Panasynk, Ya. S. Podstrigach and S. Ya. Yarema ["Questions of machine management and strength in machine construction," *Akad. Nauk USSR* **5**, no. 4, 1956], that at some distance from the faces (wall surface) the stressed state of the cylindrical portion of the boiler is principally characterized by the axial stress σ_x, for which an approximate formula is proposed

$$\sigma_x = -\alpha E\,[t - (t_0 - t_1 \cos\vartheta)]$$

Applying this formula to the calculations of actual boilers over the experimentally determined temperature fields, author arrives at the deduction that it would be possible to increase the temperature difference between the upper and lower generatrices of the boiler shell over that permitted by existing standards. Some recommendations are also made for choice of procedures for starting up and closing down the boiler. V. I. Rozenblyum

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

5402. Arzhanykh, I. S., and Bondarenko, B. A., Differential equations for the stress function of an anisotropic elastic body (in Russian), *Trudi In-ta Matem. i Mekhan. Akad. Nauk UzSSR* no. 18, 35–41, 1956; *Ref. Zh. Mekh.* no. 4, 1958, Rev. 4383.

Six differential equations are derived for the motion of an elastic anisotropic continuous medium, which contain fifteen arbitrary functions, with whose aid it is possible to form different modifications of the differential equations for the motion. The vector components of the movement are expressed through the derivatives of fifteen functions, while six functions take no part in the process at all. L. N. Ter-Mkrtich'yan

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

5403. Boley, B. A., Some observations on Saint-Venant's principle, Proc. Third U. S. Nat. Congr. Appl. Mech., June 1958; Amer. Soc. Mech. Engrs., 1958, 259–264.

Author notes that the von Mises-Sternberg proof of the Saint-Venant principle is a restricted one in the sense that it does not apply to the general boundary-value problem of elasticity. Author examines the applicability of the principle to other physical problems and extends the von Mises-Sternberg result—although the extended theorem still is not a completely general one. Author examines the Saint-Venant principle as applied to a particular transient phenomenon. Finally, he suggests a mathematical formulation of the principle based upon "upper bounds" rather than in terms of "orders of magnitude" as is done in the von Mises-Sternberg proof. S. F. Borg, USA

5404. Leonov, M. Ya., and Burak, Ya. I., A rod with an evenly stable contour of transverse section during torsion (in Russian), *Nauch. Zap. In-ta Mashinoved. i Avtomatiki, Akad. Nauk USSR* **6**, 120–125, 1957; *Ref. Zh. Mekh.* no. 4, 1958, Rev. 4422.

A search is carried out for forms of transverse sections of rods, possessing the property of stress constancy along the contour during free torsion. The deductions are based on the elementary theory of torsion [see *Nauch. Zap. In-ta Mashinoved. i. Avtomatiki, Akad. Nauk USSR* **5**, 41–45, 1956; opus cit. **6**, 109–119, 1957]. A graphical and analytical solution of the formulated problem is effected on the assumption that the transverse section has an axis of symmetry, and that the stress lines normal to the trajectories on the portion of the contour up to the intersection with the axis of symmetry are straight lines, perpendicular to the contour of the transverse section, which later converge with the axis of symmetry. Formulas are given for the determination of the tangential stresses inside the transverse section of the obtained form. The assumed character of the normal lines does not appear to be very probable. K. V. Solyanik-Krassa

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

5405. Drashkovskii, K. M., Influence of moment on contact stresses (in Russian), *Str-vo Predpriyatii Neft. Prom-sti* no. 2, 11–14, 1957; *Ref. Zh. Mekh.* no. 4, 1958, Rev. 4598.

Paper gives the results of tests for the measurement of the settlement and reactive pressures under a round rigid press, applied to the surface of a friable sandy foundation. The press, with a diameter of 48 cm, consisted of two steel disks connected by rods. The top disk was continuous, the lower consisted of separate elements connected with the top disk by means of rods. Electric strain gages were attached to the rods, enabling a pressure determination to be made, after calibration, for each element of the lower disk. The mean pressure on the press varied within the limits of 0.2 to 1.4 Kg/cm^2. The eccentricity was equal to 0, 0.125, 0.25 and 0.33 of the radius. For the central loading a parabolic diagram of reactive pressures was prepared. With eccentricity operating the diagrams also showed diminution toward the edges due to development in the soil of plastic deformation. It was shown that the theory of eccentric compression (or what comes to the same thing for a rigid press, Winkler's theory) gives diagrams for the reactive pressures, which lie in an intermediate position between the experimental and those obtained by the theory of elasticity. For the case of central loading a comparison is made between the experimental diagram and the diagram obtained in accordance with the theory of elasticity, taking into account plastic deformations; the method used for drawing the last diagram is not given.

Author holds the view that plastic deformations fulfil a more important role than is accorded them in the present times; in such discussions, however, he ignores the part played by the elastic nucleus, which forms in the soil below the press. Author also holds the view that the experimental results permit the determination of

the pitch of the press according to the formulas of the theory of elasticity, as the moduli of the soil deformations due to settlement and to pitch proved to be approximately equal. This deduction, however, runs counter to the results of the measurements of reactive pressures, in conformity with which the formula for the pitch of the Winkler theory would be nearer the actual values.

M. I. Gorbunov-Posadov

Courtesy Referativnyi Zhurnal, USSR

Translation, courtesy Ministry of Supply, England

Viscoelasticity

(See also Revs. 5373, 5562, 5590)

5406. Manacorda, T., On the mechanical behavior of a class of natural materials (in Italian), *Riv. Mat., Parma* **8**, 1/3, 15–25, 1957.

Apart from scalars (temperature, entropy, etc.) the state of any material is, in general, defined by four tensors: (1) the transformation tensor, (2) the rate of deformation tensor, (3) the stress tensor, (4) a tensor dependent on (2), (3) and the time rate of (3). Kelvin-Voigt material, by definition, depends on (1), (2), (3) only. Author considers isotropic K-V material for which, even in the case of finite transformation, a certain principle of superposition is applicable. He then is able to set up the most general rheological equation of state connecting tensors (1), (2), (3) without using empirical data. Application of this to the linearized case shows that K-V material can be thought of as a superposition of perfectly elastic material and perfectly viscous fluid. He then proves the impossibility of the propagation of ordinary waves of discontinuity in K-V material. This result is compatible with the corresponding impossibility for perfectly viscous fluid, proved by Lampariello. L. M. Milne-Thomson, USA

5407. Bland, D. R., On the foundations of linear isotropic visco-elasticity, *Proc. Roy. Soc. Lond.* (*A*) **250**, 1263, 524–549, Apr. 1959.

Author derives rigorously stress-strain relationships for a linear, isotropic, viscoelastic body satisfying some simple assumptions. Most important is the assumption that each microscopic element of the body is equivalent to a system of elastic and viscous elements. Derivation is valid for any system of stresses. Final results have essentially same form as familiar results for uniaxial tension. Relationships among various alternative formulations of linear viscoelasticity are derived. S. Gratch, USA

5408. Scott Blair, G. W., and Burnett, J., On the creep, recovery, relaxation and elastic "memory" of some renneted milk gels, *Brit. J. Appl. Phys.* **10**, 1, 15–20, Jan. 1959.

Small pressures are applied to one end of a column of renneted milk gel ("curd") in a U-tube and the displacements at the other end are magnified a hundredfold. As a first approximation, the curd behaves as a "Burgers body," except that the creep curve shows a much greater "rapid" strain than does the recovery curve. Relaxation at constant strain follows a power relation between stress and time with an exponent of 0.40. The time taken for the stress to halve itself is proportional to the initial (rapid) rate of straining. Under selected conditions, creep and relaxation curves during aging approximate to Boltzmann's superposition principle. Hysteresis curves, obtained by repeated loading and unloading, show marked stiffening, followed by a (Bauschinger) softening when the direction of loading is reversed. Following suitable stressing in alternate directions, curd shows "elastic memory," i.e. the recovery curves change direction. Such behavior necessitates additions to the Burgers model. A modification of Boltzmann's superposiiton equation is discussed and Graham's equation, which includes an Andrade term, has been applied to some of the data. The relative significance of the analytical and integrative approaches to these problems is considered.

From authors' summary

5409. Pandalai, K. A. V., and Patel, S. A., Stress distribution in multi-cellular torque boxes due to primary and secondary creep, AFOSR TN 58-1074 (Polyt. Inst. Brooklyn, Aero. Lab. Rep. 480; ASTIA AD 207 243), 22 pp., Dec. 1958.

This paper is concerned with the stress analysis of multicellular torque boxes in the presence of primary as well as secondary creep. The elastic analog is used to reduce the creep problem to one in nonlinear elasticity. The governing equations for the determination of shear flow in the torque box are derived. Particular examples for two-cell and three-cell boxes are solved numerically, and the results for shear flow and torque carried by each cell are plotted against the creep exponent which is a function of temperature.

The results indicate that the stress distribution and deformation due to creep can differ appreciably from that of the linear, elastic theory. The factors that influence this deviation are the geometry of the torque-box and the temperature.

From authors' summary by F. J. Plantema, Holland

5410. Widmer, R., Deformation mechanisms during creep in metals, *Brown Boveri Rev.* **45**, 11/12, 575–581, Nov./Dec. 1958.

Systematic creep tests were performed on a coarse-grained austenitic steel at temperatures of 650, 720 and 800 C and at stresses between 0.5 and 8 kg/mm^2. Microscopic examination and X-ray diffractograms prove that, under definite circumstances, in austenitic steel, as in aluminum and other metals, it is possible to observe a cellular mechanism during creep deformation instead of the normal slip. The nature of the deformation is studied closely in relation to the temperature and stress. Within the range considered, mainly crystallographic slip is experienced at high stresses accompanied by severe distortion of the lattice. In contrast, at medium and light stresses it is usually possible to find a cellular mechanism for which, in the process of deformation, the crystals may be subdivided into subgrains whose lattice is undisturbed. From author's summary

5411. Wahl, A. M., A comparative study of elevated temperature creep in long rotating cylinders based on various flow criteria, Proc. Third U. S. Nat. Congr. Appl. Mech., June 1958; Amer. Soc. Mech. Engrs., 1958, 685–691.

Stress distributions under steady-state creep at elevated temperature are obtained for long rotating cylinders having axial bores and subject to external radial tension. Comparison is made between stress distribution, peak stress and creep deformation at inside and outside diameter based on various flow criteria. It is found that considerable nonuniformity in stress distribution exists, regardless of the flow criterion used, the peak stress being considerably higher than the average tangential stress, particularly for small ratios of inside to outside diameter. Also creep deformations are found at the bore which are usually much higher than the nominal values based on the average tangential stress across a diametral section; the opposite is true for deformations at the outside diameter. Curves are given for determining peak stress for various diameter ratios and values of the exponent n in the power function stress-creep rate relation assumed.

From author's summary

5412. Onat, E. T., and Yuksel, H., On the steady creep of shells, Proc. Third U. S. Nat. Congr. Appl. Mech., June 1958; Amer. Soc. Mech. Engrs., 1958, 625–630.

A modified creep law which is particularly suitable for the investigation of rotationally symmetrical deformations of shells is discussed in detail. It is then applied to establish the creep behavior of cylindrical sandwich shells in terms of the stress result-

ants and deflection rates. The creep deflections of simply supported shells under the hydrostatic pressure is discussed as an example. Finite deflections of a solid circular membrane under uniform pressure is also discussed as a further example of the modified creep law. From authors' summary

5413. Patel, S. A., and Pandalai, K. A. V., Torsion of cylindrical and prismatic bars in the presence of primary creep, AFOSR TN 58-303 (Polyt. Inst. Brooklyn, Aero. Lab. Rep. 417; ASTIA AD 154 213), 12 pp., Apr. 1958.

Paper extends previous work for the case of steady creep [AMR **11**(1958), Rev. 4473] to a strain-stress-time relation representing primary creep under constant stress.

J. F. Besseling, USA

5414. Nikitina, L. P., Determination of the creep limit, taking into account the plastic properties of the material (in Russian), Testing and properties of heat-resistant materials, Moscow, Mashgiz, 1957, 189–197; *Ref. Zh. Mekh.* no. 4, 1958, Rev. 4877.

A method is proposed for determining the creep limit while taking into account the plastic properties of the material. This method is based on the use in the calculations of the constructively permissible deformation of the part for the first two periods of creep of the material. Author is of the opinion that the proposed limit of creep σ_ε permits fuller use to be made of the strength of the material, excluding at the same time the possibility of the destruction of the part in consequence of exhaustion of the reserve of plasticity. Examples are given for the determination of σ_ε for some heat-resistant materials.

Yu. G. Maksimov

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

5415. Zadoyan, M. A., The stressed state of a cylindrical tube in an elastic medium taking into account the creep of the material (in Russian), *Izv. Akad. Nauk ArmSSR Fiz.-matem. Estestv. i Tekhn. Nauk* **9,** 9, 48–65, 1956; *Ref. Zh. Mekh.* no. 11, 1957, Rev. 13185.

The determination is made of the stressed state in a cylindrical tube, the tube being in the zone of an elastic medium. The distribution is sought for the normal stresses in the tube, when the tube is under the influence of thermal changes, of shrinkage of the concrete and of even internal pressure. All these problems are investigated while taking account of creep. The general correlation between the components of the tensor of stress and the components of the tensor of deformation is expressed in an integral form of the Volterre type with a core proposed by N. Kh. Arutyunan. These correlations contain elastic constants, depending on time. All the problems given refer to cylindrical concrete tubes. Author examines influence of periodical changes of the temperature field on the stressed state in a concrete tube. Several numerical examples are cited. A. P. Bronskii

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

5416. Churikov, F. S., Equilibrium of a ring plate and disk taking creep into account (in Russian), *Uch. Zap. Severo.-Osetinsk. Gos. Ped. In-ta* no. 20, 217–226, 1956; *Ref. Zh. Mekh.* no. 11, 1957, Rev. 13189.

The experimental relation between creep deformation and stress with time during single axis loading can be expanded to take in the case of a complex stressed condition by the introduction of the intensity of the stresses and deformations. Solutions of the problems set are sought through the stress function f, which is presented in the form of the sum $f_1 + f_2$, where f_1 is the elastic solution of the investigated problem, while f_2 is determined through f by means of the building of Green's function. The problem is solved by means of successive approximations through the method of elastic solutions. O. V. Sosnin

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

5417. Tseitlin, V. Z., and Volkova, T. I., Investigation of the stress relaxation process in metals using I. A. Oding's method (in Russian), Strength of metals, Moscow, Akad. Nauk SSSR, 1956, 41–49; *Ref. Zh. Mekh.* no. 4, 1958, Rev. 4875.

Some regular features of stress relaxation are investigated and also the factors influencing the course of the process, using the method of testing for relaxation on ring-shaped samples proposed and perfected in 1944 by I. A. Oding. Results are given for the determination of the quantitative characteristics of relaxation of deflection stresses; the influence exercised by numerous factors on the course of the relaxation process is studied: exterior (temperature, stress, time) and interior (chemical composition of the material under investigation and its structural state). Recommendations are put forward regarding the contents of alloy mixes (Cr, Mo, V) which increase the relaxation resistance of steels of small carbon content at different temperatures. The question is also examined of the connection between the relaxation stability and the chemical composition of austenite steel and of alloys of nonferrous origin. The experimental results are reproduced in tables and graphs. Yu. G. Maksimov

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

5418. Sentis, A., Stationary movement in the mechanics of a continuous body (in French), *C.R. Acad. Sci. Paris* **245,** 20, 1694–1696, Nov. 1957.

Author considers a viscoelastic continuum which is characterized by a single relaxation time and a viscous effect of second order. He assumes that the displacements can be represented as a product of a growing exponential function of time and a factor depending only on position. Using this assumption, he looks at approximate solutions of the partial differential equations describing the position-dependent factor and concludes that it is possible to have repulsive forces near the origin, which fact he suggests has some connection with nuclear forces.

H. M. Trent, USA

5419. Sdobyrev, V. P., Sustained strength of alloy Je-I-437 B under combined stress (in Russian), *Izv. Akad. Nauk SSSR, Otd. Tekh. Nauk* no. 4, 92–97, Apr. 1958.

Alloy JE-I-437 B ($C \leq 0.06$, $Si \leq 0.65$, $Mn \leq 0.35$, $Fe \leq 1.00$, $Ti = 2.2$–2.7, $Cr = 19$–22, $Al = 0.5$–0.95 and Ni, $S < 0.007$, $P < 0.015$, $Cu < 0.07$, $Pb < 0.001$, $Ce < 0.1$, $B < 0.01$) was submitted at 700 C to sustained stress in simple tension, torsion and to combined stress (tension-torsion).

Logarithmic law is generally valid to represent the relationship between logarithm of failure time and applied stress but the straight line of simple tension is located above one of simple torsion and under the one of complex stress. *Relationship:* $f(\lg 100\ t) = (\sigma^2 + 1.366\ \tau^2)^{1/2}$ is valid for all three cases.

Author compares the results with those of Johnson, A. S., and Frost, N. E., [N.P.L. 31 May–2 June 1954].

K. Gamski, Belgium

5420. Ivanova, G. M., Creep of alloy Je-I-437 B under variable temperatures (in Russian), *Izv. Akad. Nauk SSSR, Otd. Tekh. Nauk* no. 4, 98–99, Apr. 1958.

Creep of alloy Je-I-437 B [see preceding review] was observed at 650 C, 700 C and at periodically variable temperature between 650 C and 700 C with three different periods 0.30, 1 and 2 hours and under sustained stress (simple tension) of 40 Kg cm^{-2}. Steady-state creep curves for variable temperature are situated between the ones observed at 650 C and 700 C.

For periodically variable temperature, the steady-state creep rate is independent of period. K. Gamski, Belgium

Plasticity

(See also Revs. 5406, 5419, 5469, 5471, 5479, 5525, 5526, 5527, 5547, 5550, 5562, 5565, 5567, 5578, 5585)

5421. Yüksel, H., Elastic, plastic stresses in free plate with periodically varying surface temperature, *J. Appl. Mech.* **25,** 4, 603–606, Dec. 1958.

Author derives equations for stresses and strains in a plate with one surface subjected to a sinusoidal temperature variation, the other surface isothermal. Plate material behavior is elastic, perfectly plastic, and plate edges are insulated and traction-free. Transient part of thermal response is not treated. For sufficiently thin plates and/or low frequency temperature oscillations, thermal stress distribution is symmetric about the midplane. Distribution is parabolic (elastic) when temperature amplitude is less than $T_0^{(1)}$, where $T_0^{(1)}$ depends on yield stress and shear modulus, thermal expansion coefficient and diffusivity, and plate thickness and temperature oscillation frequency. Distribution is parabolic plus plateau as temperature amplitude exceeds $T_0^{(1)}$; a plastic zone begins at outer fibers and progresses inward to a total of one-eighth of plate thickness when temperature amplitude reaches (64/27) $T_0^{(1)}$. Distribution exhibits upper and lower plateaus connected by parabolic arcs as temperature amplitude exceeds (64/27) $T_e^{(1)}$; plastic zone begins at midplane and progresses outward. Separation between plateaus exceeds one-eighth of plate thickness for temperature amplitudes up to $128(1-\sqrt{11/12})T_0^{(1)}$; upper plateaus extend inward approximately 0.29 times plate thickness. Response to higher temperature amplitudes is not treated. Oscillations in temperature produce thermal stress and strain cycling. Plastic zones developed during first cycle become equally plastic during subsequent cycles. W. E. Jahsman, USA

5422. Lianis, G., and Ford, H., Plastic yielding of single notched bars due to bending, *J. Mech. Phys. Solids* **7,** 1, 1–21, Nov. 1958.

A general method is developed for studying the plastic yielding of bars which are notched along one surface and subjected to pure bending under conditions of plane strain. The method is then applied to bars having a rectangular notch, a trapezoidal notch, and a V-notch with circular fillets. The results are expressed in terms of a constraint factor, defined as the ratio of the yield moment of the notched bar to the yield moment of a bar without a notch, but having a cross section equal to the minimum cross section under the notch root. In each case considered, an upper and lower bound is obtained.

Experimental checks on the constraint factors and slip line fields are also described. B. W. Shaffer, USA

5423. Ziegler, H., Cupolas with uniform stress (in German), *Ing.-Arch.* **26,** 5, 378–382, Oct. 1958.

Author investigates state of membrane stresses of spherical shells due to their own weight, requiring uniform safety against yielding in each point. Yield condition gives relation between principal stresses σ_φ and σ_ϑ in direction of meridians and parallels, respectively. Since at vertex $\sigma_\varphi = \sigma_\vartheta$, investigation starts at a point on symmetry line of the yield condition diagram. Two essentially different solutions occur, depending on the sense of circulation. Using Tresca's yield condition, the one solution is valid only up to 60 deg, thickness there becoming infinite. There the other solution gives a thickness of 16/9 of that at vertex and loses validity at 120 deg. Other laws of loading and yield conditions are also possible. W. Mudrak, Austria

5424. Storchi, E., Plastic stresses in a two-dimensional membrane of variable thickness (in Italian), *Atti Accad. Naz. Lincei, R.C. Cl. Sci. Fis. Mat. Nat.* (8) **24,** 6, 685–692, June 1958.

Author studies problems of plane plastic strain and plane plastic stress, as stated in Hill's book on "Plasticity" (Oxford, 1956; see Chap. VI for plane strain and Chap. XI, 4 for the plane stress). The two cases have their analogies in the elastic theory (see, for instance, Love's book, Chap. IX, pp. 144 and 145).

Here, also, author shows that, in plane stress, v_z (i.e. the velocity in direction z) has the expression $v_z = z\,f(x, y)$, and hence $v_x = \frac{1}{2} z^2\, df/dx + u(x, y)$, $v_y = \frac{1}{2} z^2\, df/dy + v(x, y)$. He deduces also the differential equations for solving the problem of plane stress.

Reviewer thinks that the paper is interesting, but some statements have to be revised. It is not exact, for instance, that solutions of plane stress are independent of z, but author completely rectifies this statement (on page 687) in writing the formulae (1'"), (2'"), (4'") (of page 690).

It develops that dependence of z in plane plastic stress is very similar to the dependence of z in plane elastic stress.

G. Supino, Italy

5425. Murch, S. A., and Naghdi, P. M., On the infinite elastic perfectly plastic wedge under uniform surface tractions, Proc. Third U. S. Nat. Congr. Appl. Mech., June 1958; Amer. Soc. Mech. Engrs., 1958, 611–624.

Under Tresca's yield condition, authors obtain plane strain and plane stress solutions with emphasis on the former. Solution for wedge with angle $0 \leq \beta \leq 2\pi$ is categorized according to whether yield begins internally or externally. General expressions are obtained for plane strain, and complete solution is given for wedge $\beta < 128.726$ with uniform shear on one face. Numerical solution is shown for $\beta = \pi/2$. Associated plane stress solution with special reference to wedge is discussed. Paper ends with remarks on nonsymmetry of stress tensor at corner element of quarter plane allowed by discontinuity, since Cauchy's proof depends on continuity. B. Bernstein, USA

5426. Il'yushin, A. A., Some questions of the theory of plastic flow (in Russian), *Izv. Akad. Nauk SSSR, Otd. Tekh. Nauk* no. 2, 64–86, Feb. 1958.

Basic assumptions of a theory of plastic flow, developed in author's previously published papers, are presented. This theory relates components of stress and velocity strain deviators in a similar fashion as does the theory of elastic-plastic deformations ("deformation theory") with respect to stress and strain deviators. Theorems concerning this similarity are reviewed. A constitutive equation for metals is proposed in terms of temperature, velocity strain and a specified function of logarithmic strains. In a set of equations of the theory in question, conditions of the thermal balance are included. As an example a particular problem of plastic flow and heat exchange between rough surfaces for the case of temperature-dependent yield limit is studied, corresponding variation in the thickness of the deformable layer being evaluated.

Also the flow theory of an incompressible perfectly plastic material and methods of forming shells by extrusion are discussed, using a sand-hill analogy to calculations of extruding forces.

In general, paper gives a review of results discussed in detail in the references. A. Sawczuk, USA

5427. Glikman, L. A., Stability of residual stresses and their influence on the mechanical properties of the metal and the strength of the manufactured articles (in Russian), *Trudi Leningrad Inzh.-Ekon. In-ta* no. 13, 145–203, 1956; *Ref. Zh. Mekh.* no. 3, 1958, Rev. 3518.

Author makes the following deductions, on the basis of the analysis of experimental investigations (his own and those of other authors) cited in the literature. (1) The stability (conservation) of

residual stresses during prolonged exposures at room temperature is, for steels, very high (a lowering of 6–8%); the actual material reduction takes place commencing from 300°. (2) With static loading the residual stresses are stable as long as the sum total of stresses (residual and those arising from an external load) do not overstep the elastic limit; with the appearance of residual deformation of 0.5 to 1% the residual stresses diminish. (3) With cyclic loading the residual stresses are noticeably reduced when the sum total of stresses exceeds the cyclic limit of elasticity. The method of reducing residual stresses by making use of cyclic reaction can not be recommended. (4) For plastic materials the residual stresses, for both homogeneous and heterogeneous stressed conditions, show no influence on the stability. The residual stresses when in a homogeneous stressed condition effect a reduction in the limits of proportionality, elasticity and yield. (5) For brittle materials, or for plastic materials with a tendency to brittle fracture (when the temperature is lowered, when the speed of loading is increased, when the material is incised), the residual stresses when in a homogeneous stressed condition always reduce the stability, while in a heterogeneous stressed condition, depending on their distribution, the stability is either enhanced or reduced. (6) Residual stresses bearing a linear or plane character do not indicate any influence on any tendency of the metal to brittle fracture, but with a three-dimensional character may induce a brittle condition. (7) Residual compression stresses in the surface layer increase, while similar tension stresses decrease, the fatigue resistance during deflection (the amplitude of the cycle on the limit of fatigue). A. D. Kovalenko

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

5428. Trofimov, V. I., The position of plastic deformations in test samples during tension (in Russian), Investigations on steel structures, Moscow, 1956, 59–67; *Ref. Zh. Mekh.* no. 3, 1958, Rev. 3515.

An investigation of structural steel Mark St3 of five different smelts (smelting processes) showed that in tension all of the samples had a clearly defined surface of yield, some 1.5–2% in length. When loaded at a speed of 1–3 kg/mm² in 1 sec, clearly-defined upper and lower limits for the yield are visible right up to the upper limit of yield; when loaded at a speed of 0.05–0.08 kg/mm² in 1 sec, the upper limit of yield is not observable. The yield started in the portions where local re-stressing in the elastic stage was at its maximum. First of all yield appeared on the bounded portion and the elongation there reached 1.8–2.2%, that is the elongation of the whole surface of plastic flow; further development of deformation took place at the expense of the subsequent transition of the elastic zones to the plastic. The zone of residual deformations coincided exactly with the portion covered by Chernov-Luders lines. I. M. Gryaznov

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

5429. Sobolevskii, V. M., Elastic and elastic plastic stressed condition of a round cylindrical tube in an elastic medium under the action of an internal pressure (in Russian), *Uch. Zap. Belorussk. In-ta Nar. Kh.-va.* no. 3, 207–252, 1957; *Ref. Zh. Mekh.* no. 4, 1958, Rev. 4548.

The elastic-plastic deformation is investigated of an isotropic cylindrical tube, located in an elastic medium, under the action of an even internal pressure, an axial force and a temperature which is a function of the radius. Cases are examined with Guk's medium and Winkler's medium. The solution is derived on the assumption that there is one zone of plastic condition adjacent to the inner surface of the tube. V. A. Lomakin

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

5430. Chekmarev, A. P., and Ridior, Z. A., The actual resistance to plastic deformation of carbon steels at high temperatures and velocities of deformation (in Russian), *Trudi In-ta Chernoi Metallurg. Akad. Nauk USSR* **11**, 18–32, 1957; *Ref. Zh. Mekh.* no. 4, 1958, Rev. 4883.

An investigation was carried out on the influence of the conditions of deformation (temperature t, velocity of deformation v, degrees of deformation ε) on the resistance s of carbon steels when in uniaxial tension. The formula $s = P(1 + \varepsilon)/F_0$ was used, where P and F_0 are the force and the initial area of the transverse section, respectively. A description is given of the apparatus used in the experiments for rapid intermittent determinations, enabling $v = 400\ \text{sec}^{-1}$ to be attained. The recording force-measuring device guaranteed the recording of frequency processes up to 400 Hertz with a minimum time for the test of 1/300 secs. The test samples—cylinders with ratio of thickness to length of 1/6—were heated to 800–1200°. On the results of tests on steels marks 10, 20, 45, U7A and U10A, certain deductions were made; in addition to the generally known data the position appears to be that s increased with the increase of v and ε, but depends on the carbon content; however, s decreases with the growth of C in the case of certain steels. I. K. Snitko

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

5431. Kats, Sh. N., and Kachanov, L. M., On plastic deformations under complex loading (in Russian), *Izv. Akad. Nauk SSSR, Otd. Tekh. Nauk* no. 11, 172–176, 1957.

The study pertains to plastic deformation caused by a compound load. Author is concerned with tests in which a tubular specimen subjected to internal pressure was twisted. Previous work by W. Shepherd, J. A. Morrison, and Shepherd, Phillips and A. Zhukov is quoted. A wide gap between experimental and theoretical data is noted. M. G. Bekker, USA

5432. Voce, E., Influence of strain hardening on the dilation of cylinders under internal pressure, *Engineering* **185,** 4814, 756–759, June 1958.

An analytical treatment of plastic expansion of thick-walled tubes under internal pressure. Voce's exponential strain-hardening function is used and shown, by reference to experiment, to give satisfactory results. In addition to an exact, fully integrated solution, author gives a simplified method assuming a constant yield stress across the cylinder wall. The discrepancy between the two did not exceed 3.6%. Bulging (incipient failure) pressure is calculated from the strain-hardening properties, and it is suggested that the maximum shear yield criterion is preferable to the Huber-Mises criterion both for dilation of tubes and for torsion of bars. N. H. Polakowski, USA

5433. Ford, H., and Lianis, G., Plastic yielding of notched strips under conditions of plane stress (in English), *ZAMP* **8,** 5, 360–400, Sept. 1957.

Using the stress trapezoid as statically admissible stress field and the von Mises yield condition, authors find a lower bound for the case of a circular and V-notched strip specimens. Results are compared with the upper bounds obtained by Hill [*J. Mech. Phys. Solids* **1**, p. 19, 1952] using the theory of characteristics. For the V-notched case and for $0 \leq \alpha \leq 67°$ (α notch semiangle) the lower bound is coincident with Hill's upper bound. For $67° \leq \alpha \leq 90°$ it is almost coincident. These results are in agreement with Bishop's proof [*J. Mech. Phys. Solids* **2**, p. 43, 1953; AMR **7** (1954), Rev. 1793] that Hill's upper bound is the true solution.

For the circularly notched strip the lower bound is so close to Hill's upper bound that it seems that in this case also Hill's solution is the true solution.

The main purpose of the paper is to find upper and lower bounds of the single notched strip subjected to bending in the plane of the

sheet. Upper bounds are determined using the theory of characteristics. A lower bound is found using the stress trapezoid together with the addition of a uniformly stressed band.

In the V-notched strip and $0 \leq \alpha \leq 67^\circ$ upper and lower bounds are coincident, for $67^\circ \leq \alpha \leq 90^\circ$ the two bounds are practically coincident. In the case of the circular notch also upper and lower bounds are nearly coincident. C. A. Sciammarella, USA

Rods, Beams and Strings

(See Revs. 5480, 5516, 5573, 5578)

Plates, Shells and Membranes

(See also Revs. 5412, 5421, 5423, 5429, 5473, 5476, 5477, 5484, 5485, 5526, 5582, 5605, 5606)

5434. Csonka, P., Pileate shaped membrane above rectangle (in Hungarian), *Magyar Tud. Akad. Musz. Tud. Oszt. Köz.* **22,** 1/3, 21–33, 1958.

5435. Stanek, F. J., Uniformly loaded square plate with no lateral or tangential edge displacements, Proc. Third U. S. Nat. Congr. Appl. Mech., June 1958; Amer. Soc. Mech. Engrs., 1958, 461–466.

The Ritz energy method is used in connection with nonlinear theory of elastic plates. For the displacements, 1-term, 3-term and 4-term expressions are adopted, satisfying the boundary conditions, that is, nullifying the tangential displacements, the bending moments and the normal stresses along the edges of the square plate. The calculations are carried out for load values yielding maximum deflections up to 8.5 times the plate thickness. The 3-term and 4-term approximations agree substantially. The maximum principal stresses appear to occur along the edges at quarter points. P. Cicala, Italy

5436. Vlasov, B. F., On the equations of plate flexure (in Russian), *Izv. Akad. Nauk SSSR, Otd. Tekh. Nauk* no. 12, 57–60, Dec. 1957.

Author determines the state of stress of the plate with an arbitrary shape submitted to a transverse load and to the bending and torsional moments and shearing forces distributed on the edge. The plate has a constant thickness. Author considers the influence of the shearing stresses and assumes that the points lying on the normal to the middle plane before the deformation are situated later on a curve corresponding to the parabolic course of shearing stresses in relation to the plate thickness.

Using the Lagrangian variation condition, author derives the equilibrium equations and the edge conditions, but the solutions of the fundamental differential equations are not quoted by the author. J. Valenta, Czechoslovakia

5437. Ovakimyan, S. G., Deflection of a thin rectangular plate, sealed along the whole length of its edges (in Russian), *Sb. Naucb. Trudl Erevansk. Politekbn. In-ta* no. 14, 3–12, 1957; *Ref. Zb. Mekb.* no. 4, 1958, Rev. 4477.

Using the method of conforming reflection an investigation is made of the deflection of a thin rectangular plate, sealed along the whole length of the edges. The problem is solved for two forms of loading: a load evenly distributed over the whole surface of the plate and a load distributed over the area of a circle with radius R, the center of which is coincident with the center of the plate. The latter, as a limit, gives rise to the case of concentrated forces, applied at the center. For different ratios b/a of the sides of a rectangular plate values are obtained for the deflection in the center of the plate. In the special case of a square plate and with $b/a = 0.5$, under a continuous even loading these values are compared with the results obtained by other authors using different methods for their calculations.

D. V. Peshtmaldzhyan
Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

5438. Chatterjee, B. B., Note on the bending of a thin uniformly loaded plate bounded by two equal confocal parabolas, *Indian J. Theor. Phys.* **6,** 1, 35–37, Mar. 1958.

In this note the bending of a thin uniformly loaded plate bounded by two equal confocal parabolas is discussed. The boundary is assumed to be clamped and the plate bent by transverse forces. From author's summary

5439. Gol'denveizer, A. L., On Reissner's plate theory (in Russian), *Izv. Akad. Nauk SSSR, Otd. Tekh. Nauk* no. 4, 102–109, Apr. 1958.

Author discusses the assumptions of E. Reissner's theory of plates, presented in the papers: *J. Math. Phys.* **23,** 184–191, 1944, and *Quart. Appl. Math.* **5,** 1, 55–68, Apr. 1947 [AMR **1,** Rev. 59]. Based on the analysis of a circular plate, author states that Reissner's theory describes properly the qualitative character of the phenomena but that it may lead to inaccurate values of corrections to the classical theory of thin plates. This is due to the fact that Reissner's corrections are (or at least may be) mainly dependent on conditions at the boundaries where the assumed stress distribution may be different from the real one.

At the end of the paper, author discusses B. F. Vlasov's theory of bending of plates [*Izv. Akad. Nauk SSSR, Otd. Tekh. Nauk* no. 12, 57–60, Dec. 1957] and shows that Vlasov's assumptions essentially reduce to those of Reissner. M. P. Bieniek, USA

5440. Chapkis, R. L., and Williams, M. L., Stress singularities for a sharp-notched polarly orthotropic plate, Proc. Third U. S. Nat. Congr. Appl. Mech., June 1958; Amer. Soc. Mech. Engrs., 1958, 281–286.

Continuing a series of investigations into the character of possible bending or extensional stress singularities in the vicinity of angular or sharp-notched inclusions in thin plates of uniform thickness, the authors have now studied the effect of radial and circumferential orthotropy. Characteristic equations for all the usual boundary conditions are derived (without being evaluated numerically, however, as was done in the earlier papers of the series), and the qualitative effect of orthotropy upon the character of the stress is determined for the particular case of a cracked plate under free-free extensional (or clamped-clamped bending). A stronger stress singularity is indicated if the shear rigidity exceeds the radial rigidity.

From authors' summary by Y.-Y. Yu, USA

5441. Conway, H. D., A Levy-type solution for a rectangular plate of variable thickness, *J. Appl. Mech.* **25,** 2, 297–298 (Brief Notes), June 1958.

5442. Essenburg, F., On axially symmetrical plates of variable thickness, *J. Appl. Mech.* **25,** 4, 625–626 (Brief Notes), Dec. 1958.

Effects of shear deformation and transverse normal stress are accounted for according to Reissner's theory [AMR **4** (1951), Rev. 2381]. In comparison with the classical theory, only the load terms in the final equations are modified; therefore well-known solutions are readily extended. For a ring plate, with thickness proportional to radius, subjected to a load acting along the symmetry axis, results are compared with classical theory predictions. P. Cicala, Italy

5443. Wempner, G. A., and Schmidt, R., Large symmetric deflections of annular plates, *J. Appl. Mech.* **25,** 4, 449–452, Dec. 1958.

Paper presents analysis of deflections and stress resultants and couples for the large deflection case of circular annular plates loaded by normal shears applied uniformly around the edges. Solutions are obtained in the form of what are effectively power series in log r, where r is the distance from the center. Plots are given of numerical results for a special case. These were obtained by using a high-speed computer. Good agreement is found with an approximate solution due to Wempner [Proc. 3rd U. S. Nat. Congr. Appl. Mech., 1958.] W. S. Hemp, England

5444. Medwadowski, S. J., A refined theory of elastic, orthotropic plates, *J. Appl. Mech.* **25,** 4, 437–443, Dec. 1958.

Theory presented contains nine elastic constants and includes the effect of transverse shear deformation and transverse normal stress. Equations characterizing a nonlinear plate theory are derived from corresponding equations of three-dimensional elasticity theory. Theory includes terms characterizing body and inertia forces and an elastic foundation.

Linearization of the equations permits the introduction of a stress function satisfying a single sixth-order partial differential equation. A solution is presented and discussed.

R. A. Eubanks, USA

5445. Soper, W. G., Large deflection of stiffened plates, *J. Appl. Mech.* **25,** 4, 444–448, Dec. 1958.

Using an equivalent orthotropic representation of reinforced plates due to Hoppmann [*J. Appl. Mech.* **22,** p. 267, 1955], author develops equations for large deflections under lateral load. Rectangular plates under varying edge rotational constraint are analyzed by Fourier representation of normal displacement and membrane stress function. Equations for the coefficients are very complicated and are solved by successive approximation. Good agreement is obtained with results of experiments.

W. S. Hemp, England

5446. Nomachi, S., On bending of a rectangular cantilever plate (in Japanese), *Trans. Japan Soc. Civ. Engrs.* no. 60, 20–29, Jan. 1959.

In this paper bending of a rectangular cantilever plate, that is a plate with three free edges and one clamped edge, is considered. The function denoting the deflection of the plate is, by virtue of the finite double Fourier transforms, written in a double series with respect to sine and cosine. Some numerical examples are presented. From author's summary

Courtesy, Editorial Committee of the Japan Society of Civil Engineers

5447. Siess, C. P., Re-examination of Nichols' expression for the static moment in a flat slab floor, *J. Amer. Conc. Inst.* **30,** 7, 811–813 (Concrete Briefs), Jan. 1959.

5448. Pirogov, I. M., Distribution of stresses in the region of an opening on the surface of a round cylinder (in Russian), *Sb. Statei Vses. Zaochn. Politekhn. In-ta* no. 15, 48–52, 1956; *Ref. Zh. Mekh.* no. 4, 1958, Rev. 4445.

The problem is examined of the stress determination in the area of an opening in a cylindrical shell, loaded by moments M evenly distributed over the opening. It is assumed that the radius of the opening is small by comparison with the shell's dimensions. The solution of the problem merges with the finding of a complex function of stresses. Simple final expressions are put forward for the moments and forces in the vicinity of the opening. In the absence of curvature the specific forces are converted to a zero value, while the moments become equal to the corresponding moments in an infinite plate with a round orifice, loaded by distributed moments over the orifice. A table had been compiled to compare the results of the solution of the investigated problem with the results of the solution of the analogous problem of the plate; this gives the values of the normal stresses along the contour of the opening, created by the deflecting moments and the tensioning forces for various values for the shell's parameter. Poisson's ratio for the purposes of these calculations was taken to be equal to 1/3.

Yu. G. Maksimov

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

5449. Saleme, E. M., Stress distribution around a circular inclusion in a semi-infinite elastic plate, *J. Appl. Mech.* **25,** 1, 129–135, Mar. 1958.

See AMR **11** (1958), Rev. 1549.

5450. Black, L. D., Relative strengths of plates on elastic foundation, *Trans. Engng. Inst., Canada* **2,** 3, 129–131, Sept. 1958.

Model studies have been carried out to determine the dependence of breaking strength on apex angle for elastic sectorial plates on elastic foundation. Size—and shape—dependence were studied for the unbroken sheets. It is concluded that the breaking strength is approximately linearly related to the apex angle for the sectorial plates. From author's summary

5451. Gold, L. W., Black, L. D., Trofimenkof, F., and Matz, D., Deflections of plates on elastic foundation, *Trans. Engng. Inst., Canada* **2,** 3, 123–128, Sept. 1958.

Experimental observations were carried out on the deflection of a large plate with a concentrated load applied at the center; of a large half-plate with a concentrated load applied at the free edge; and a large sectorial plate with a concentrated load applied at the tip. The results of this study were used to determine the rigidity modulus of ice from observations made in the field. Conclusions are drawn concerning the relative bearing strength of the center-loaded and edge-loaded plates. From authors' summary

5452. Kollar, P., Stability of struts on elastic foundation (in Czech., *Stavebnicky Casopis* **6,** 1, 8–17, 1958.

5453. Fedenko, G. I., Dynamics calculation of ships' plates reinforced by rigid ribs (in Russian), *Sudostroenie* no. 10, 4–8, 1956; *Ref. Zh. Mekh.* no. 4, 1958, Rev. 4706.

Calculation formulas are derived for plates, freely supported along two edges and rigidly fastened on flexible ribs, when under the action of an evenly distributed load, varying in accordance with the harmonic principle. A. A. Kurdyumov

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

5454. Vinson, J. R., Thermal stresses in laminated circular plates, Proc. Third U. S. Nat. Congr. Appl. Mech., June 1958; Amer. Soc. Mech. Engrs., 1958, 467–471.

General equations are derived for an elastic, thin, circular plate, composed of two isotropic layers, under arbitrary boundary conditions, subjected to an arbitrary axisymmetric temperature distribution represented by Fourier expansions along the radius.

Reviewer notes that in Eq. [26] and subsequent ones C_1 should be replaced by $-C_1$. P. Cicala, Italy

5455. Owens, R. H., Flexibility analysis of piping systems formulated for digital computer solution, Proc. Third U. S. Nat. Congr. Appl. Mech., June 1958; Amer. Soc. Mech. Engrs., 1958, 419–430.

The analysis is general within the framework of small-deformation theory. In addition to a consideration of shear and tensile forces, a completely arbitrary distributed loading is imposed on the system. A general scheme for setting up the equations relating

the loadings to the deformations is given for a system with any number of anchors and constraints. Formulas for the flexibility matrices and those matrices which govern the effect of the distributed loading on deformation are derived for straight sections and plane bends. All computations may be carried out easily on a digital computer. From author's summary

Book—5456. Vlasov, V. Z., General shell theory and its application in technology [Allgemeine Schalentheorie und ihre Anwendung in der Technik], Berlin, Akademie-Verlag, 1958, xi + 661 pp. 75 DM.

This is a translation into German of the work on shells that was originally published in Russian in 1949. The book is divided into five parts, Part I, "Membrane theory of shells," with four chapters treating (1) shells of rotation, (2) various second-order surfaces, (3) closed ellipsoidal and spherical shells, and (4) shells of negative Gaussian curvature. Chapters (3) and (4) contain solutions of many boundary-value problems involving concentrated load effects that have not appeared in the literature previously. Part II, "General theory of bending resistant shells," consists of chapters (5) fundamental three-dimensional elasticity equations in curvilinear coordinates and (6) fundamental equations of general shell theory. In (6) the basic equations applicable to thick shells are derived from equations obtained in (5). Special cases of cylindrical and spherical shells are discussed but no boundary-value problems are solved.

In Part III, "Theory and calculation methods for shallow shells," the equations obtained in (6) are specialized in chapter (7) to the case of thin shallow shells. Here the symmetric pair of simultaneous linear equations governing shallow shell behavior are presented. These have previously been discussed [AMR **5** (1952), Rev. 365]. These equations represent an approximation to the well-known Reissner equations in that the Vlasov equations omit in the rotation components terms involving displacements in the middle surface of the shell and retain for these rotations only normal displacements and their derivatives. These equations would appear to be unsuitable for problems in which the reference surface undergoes a nearly inextensional deformation. In chapters (8) and (9), the shallow-shell equations are applied to boundary-value problems involving cylindrical and spherical shells, respectively. Chapter (10) presents the extension of these equations to the case of finite deflections, essentially a generalization of the von Karman plate equations.

Part IV, "Orthotropic cylindrical shells," is divided into chapter (11) presenting basic equations for small deformations and (12) methods of calculating cylindrical shells of intermediate length. Boundary-value problems involving radial loads on cylindrical shells, as well as various loads on open cylindrical shells, are presented. Part V, "Thin-walled supporting structures," presents in chapter (13) the analysis of thin prismatic construction in the case of negligible shear stiffness and in chapter (14) the analysis of such structures with consideration of shear deformations.

The book concludes with tables of functions useful in the numerical analysis of shallow shells. W. A. Nash, USA

Book—5457. Cravino, P. B. F., Theory and calculation of shells—shells of revolution (Teoria e Calculo das Cascas—Cascas de Revolucao), Sao Paulo, Brazil, Escola Politecnica de Universidade de Sao Paulo, 1957, xii + 335 pp.

This is a textbook on linearly elastic thin shells, particularly on those shaped like surfaces of revolution; at the same time it is a handbook for their calculation.

In part I author derives fundamental equations of surface structures from the basic elements of differential geometry, equilibrium equations, and analysis of deformation. From these general equations, theory of elastic slices, plates, and shells of revolution are derived as particular cases. Part II is devoted to the study of elastic shells with membrane behavior. Simplication of non-existence of moments is introduced in general equations, and solutions are found for closed and open, spherical and conical, and cylindrical membranes.

Part III covers topics about flexural theory of shells of revolution, with linearly elastic behavior and axially symmetric loads. Exact equations of Meissner are derived from general theory and integrated for particular cases (spherical, conical, cylindrical shells). Support reactions are computed through both elastic and static unknown methods. Approximate theories (Blumenthal's, derived asymptotic method, Geckeler's) are applied for solving practical cases. Last chapter is devoted to flat spherical shells.

Reviewer points out two principal merits of this book: unity is obtained by deducing every single problem from general theory, as particular or limit case; plenty of numerical examples, figures and tables give it real usefulness for students and engineers. It would be desirable to see a sharper distinction between those parts of the theory which are of general validity, and those which are only valid for linearly elastic structures; also, use of finite-difference methods. H. Fernandez Long, Argentina

5458. Morley, L. S. D., An improvement on Donnell's approximation for thin-walled circular cylinders, *Quart. J. Mech. Appl. Math.* **12,** 1, 89–99, Feb. 1959.

In order to compute the stress resultants of the thin-walled circular cylinder, Flügge's three differential equations for the displacements u, v, w may be used. After having computed the displacements u, v, w, by means of well-known formulas, the stress resultants from u, v, w derive. The use of Flügge's differential equations is fairly laborious. To avoid this difficulty, Donnell has neglected certain terms of the differential equations. In consequence of this, in certain cases the accuracy of the result becomes insufficient. In the present paper, certain other terms are neglected, and by this means the accuracy of the result improved. Flügge's differential equations were used here as a standard for comparison. J. Barta, Hungary

5459. Krstic, M., A doubly-curved shell roof in Belgrade, *Concrete Constr. Engng.* **54,** 2, 73–80, Feb. 1959.

Paper describes construction of reinforced-concrete roof, whose spherical surface is bounded by one horizontal and two parallel vertical planes. Shell is stiffened by edge beams and at four corners is prestressed with high-tensile steel cables. Design equations based on membrane theory are given, but how displacements and/or loads predicted by equations compare with practice is not stated. D. M. A. Leggett, England

5460. Johnson, M. W., and Reissner, E., On the foundations of the theory of thin elastic shells, *J. Math. Phys.* **37,** 4, 371–392, Jan. 1959.

Paper discusses semi-infinite circular cylindrical shell loaded by axially symmetric surface tractions on the end cross section. Stresses and displacements are assumed in the form of an expansion with respect to $\lambda = h/2a$ (h is shell thickness, a is mean radius), which is expected to have asymptotic character near $\lambda = 0$. Coefficients of equal powers of λ in the three-dimensional equations are equated, and the resulting equations are integrated with respect to the radial coordinate in order to define the "macroscopic" quantities of shell theory. The equations are solved in the first and second approximation (corresponding to λ^0 and λ^1), and the results are compared to classical shell theory. The numerical evaluation of the stress distribution for $\lambda = 1/5$ is discussed in detail, and the influence coefficients for bending and transverse shear are also obtained. It appears that the corrections of classical shell theory for the influence coefficients are less than 2% for $h/a = 0.1$. Moreover, it is shown that transverse shear stresses and transverse normal stresses have an effect on these corrections of the same order as the well-known Flügge-Byrne corrections in classical shell theory.

W. T. Koiter, Holland

5461. Librescu, L., Some problems of the theory of a class of nonhomogeneous elastic thin shells (in Roumanian), *Studii Si Cercetari Mecan. Appl.* **10,** 1, 187–202, 1959.

Paper concerns an extension of the correspondence established through the static geometrical analogy in the case of isotropic thin shells to structures consisting of an odd number of isotropic layers placed symmetrically with respect to the middle surface.

The analogy is then applied to the determination of the stress state in shallow structures subjected to external loads and placed in a nonuniform temperature field.

A. Petre, Roumania

5462. Gerard, F. A., The analysis of a cylindrical shell roof with edge beams, *Trans. Engng. Inst., Canada* **2,** 4, 168–174, Dec. 1958.

Author presents an entirely new approximate procedure differing radically from the usual methods for the calculation of shells with two vertical planes of symmetry. As displacement functions he proposes to choose expressions consisting of two factors, the first of which is a polynome, the second a trigonometrical number. The three displacement functions contain altogether seven indefinite parameters. The following boundary conditions are employed: (1) the edge beams undergo no torsion; (2) the rate of change of the tensile force in the edge beams is equal to the shear force acting on the beams by the shell; (3) the horizontal displacements of shell and edge beams at their junction are equal. Similar boundary conditions for the vertical displacements are however not fulfilled; they are considered implied in the strain energy function. Thus to solve the problem, four equations are still necessary, i.e. the strain energy function must be derived partially with respect to the four parameters still free.

Author illustrates the theory discussed by worked out examples, among others by those with prestressed edge beams. He compares the results obtained with those of other known methods of calculation. The differences are quite significant, and it would be very desirable to clear up the reasons of this inadmissible discrepancy.

The method proposed is clearly explained and may be considered as relatively simple, and therefore may be seriously recommended for engineering bureaus.

P. Csonka, Hungary

5463. Klein, B., Effects of local loadings on pressurized circular cylindrical shells, *Aircr. Engng.* **30,** 358, 356–361, Dec. 1958.

The deflections and stresses in the region of a highly localized loaded area of a pressurized circular cylindrical shell are calculated. Four types of loading are considered: uniformly distributed radial and tangential loadings and linearly distributed longitudinal and circumferential bending moments. The results are presented as dimensionless ratios in terms of five basic parameters defining the geometry of the cylinder and loading and the magnitude of internal pressure. A very large number of terms in the series solution were evaluated for the assumed position of maximum stresses for some 81 combinations of the parameters. Equation 2 contains some obvious and some not-so-obvious misprints.

G. Sved, Australia

5464. Marin, J., and Rimrott, F. P. J., Plastic design of thick-walled pressure vessels, *Welding J.* **37,** 12, 570s–576s, Dec. 1958.

Paper is a critical review of available theories which purport to predict strength of thick-walled cylindrical vessels. Shortcomings of each are noted and a new theory is proposed based on true stress-strain properties of the material and considering possibility of large plastic strains. Proposed theory is to be published elsewhere, but paper presents an approximate maximum pressure expression suitable for design. Authors state that proposed theory is similar to that of Nadai ["Plasticity," McGraw-Hill, 1931] except the tensile stress-strain relation is used in place of the shear stress-strain relation. Comparisons with test results and with similar expressions from ASME Boiler Code are presented. See also Svensson, N. L. [AMR **11** (1958), Rev. 2065].

G. P. Fisher, USA

5465. Wood, J. D., The flexure of a uniformly pressurized, circular, cylindrical shell, *J. Appl. Mech.* **25,** 4, 453–458, Dec. 1958.

Paper examines flexure of a uniformly pressurized, long, closed, circular, cylindrical shell. Moment-curvature relationship and cross-sectional components of displacement are presented. Shell, loaded in one of its principal planes by two equal and opposite terminal couples, is first made to undergo small initial displacements. These are formed by superimposing pressurization displacements upon Saint-Venant displacements. From this deformed position the shell is perturbed into a system of additional small displacements. A Rayleigh-Ritz technique is used to find the latter displacements from the theorem of minimum potential energy. The point at which the moment-curvature relationship becomes nonlinear is shown by several curves.

A. W. Coutris, USA

5466. Przemieniecki, J. S., Matrix analysis of shell structures with flexible frames, *Aero. Quart.* **9,** 4, 361–394, Nov. 1958.

Paper is an application of matrix force method of reviewer [see "Energy theorems and structural analysis," *Aircr. Engng.* **26,** Oct., Nov., 1954; **27,** Feb., Mar., Apr., May 1955] to cylindrical fuselages of arbitrary but single-cell cross section. Best feature of work is selection of self-equilibrating systems based on five-boom open tubes [see, for corresponding theory: Argyris, Dunne, "General theory of cylindrical and conical tubes," *J. Roy. Aero. Soc.* **53,** May, June, 1949]. These systems ensure, in general, very good conditioning of equations in the redundant forces. The rings in the basic system are left open—an arrangement open to improvement. The work appears to be intended for a manual formation of the basic matrices and does not discuss their systematic formation in the digital computer; questions of programming are not mentioned either.

J. H. Argyris, England

5467. Oravas, G.-A., On the theory of nearly spherical thin shells (in English), *ZAMM* **38,** 9/10, 379–386, Sept./Oct. 1958.

The approximate analysis of nearly spherical thin elastic shells of revolution with constant thickness in the case of a boundary perturbation is carried out by a method of successive corrections as introduced into the theory of thin shells by E. F. Burmistrov.

The basic system of two differential equations determining the transverse bending behavior of thin shells of revolution is reduced to a single second-order equation with complex coefficients. All the quantities entering into this equation are developed into power series of the small parameter measuring the deviation of the shell from the spherical form. Introducing these series in the above-mentioned second-order equation and setting the coefficient of every power of the basic parameter equal to zero leads to an infinite set of differential equations admitting the use of successive corrections.

Results of this paper are to be considered as a new approximate solution in the theory of thin elastic shells of revolution.

V. Vodicka, Czechoslovakia

5468. Lunchick, M. E., Yield failure of stiffened cylinders under hydrostatic pressure, Proc. Third U. S. Nat. Congr. Appl. Mech., June 1958; Amer. Soc. Mech. Engrs. 1958, 589–594.

Author presents experimental results for seven ring-stiffened cylindrical shells which failed by axisymmetric yielding when subjected to external hydrostatic pressure. He compares the experimental collapse pressures with several theories. Correlation is within 10% for (a) Sanden-Gunther analysis for the middle surface stresses at mid-bay and using the Mises yield criterion; (b) Hodge's rigid-plastic analysis; and (c) the author's method. The latter assumes the stress resultants and stress couples are linear functions of the pressure up to failure.

Correlation between experiment and theory is best using author's method. However, it is difficult to make an assessment of the various theories since duplicate tests were not conducted and initial out-of-roundness, while mentioned by the author, was neglected in the numerical comparisons.

G. D. Galletly, USA

5469. Paul, B., and Hodge, P. G., Jr., Carrying-capacity of elastic-plastic shells under hydrostatic pressure, Proc. Third U. S. Nat. Congr. Appl. Mech., June 1958; Amer. Soc. Mech. Engrs., 1958, 631–640.

Paper deals with the limit load of a short, simply-supported, cylindrical shell subjected to external hydrostatic pressure. The beam-column effect is taken into account. An approximate value for the limit load of completely plastic shells is given in explicit form and a complete elastic-plastic solution is presented for a particular numerical example. For this example, the approximate and elastic-plastic solutions predict the same carrying capacity, which is 14% smaller than that predicted by a rigid-plastic solution.

Authors also discuss limitations of their results and suggest that the analysis could probably be extended to shells with other conditions of end fixity. G. D. Galletly, USA

5470. Khlebnoi, Ya. F., A practical method for the calculation of an axially symmetrical shell with variable wall thickness (in Russian), *Sb. Trudî Mosk. Inzh.-stroit. In-ta* no. 17, 97–115, 1957; *Ref. Zh. Mekh.* no. 4, 1958, Rev. 4433.

An investigation is made of the axially symmetrical deformation of a thin-walled shell the thickness of which changes proportionally to the distance from the cone's apex. An exact solution is given, simplified in form to the extent of its being suitable for practical application. Long shells are investigated in greater detail for cases where forces applied to one boundary of the shell do not evoke deformations in its other boundary. For the latter case formulas are furnished for the change of position of the shell boundaries due to the action on them of a single generalized force. Special cases are looked into concerning the action of some forms of loading on a lateral surface of a shell. A numerical example is given. A. D. Pospelov

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

5471. Tsurkov, I. S., Elasto-plastic deformations of orthotropic cylindrical shells (in Russian), *Izv. Akad. Nauk SSSR, Otd. Tekh. Nauk* no. 12, 50–53, Dec. 1957.

On the basis of the step-by-step method author gives the solution of an orthotropic cylindrical shell. For the complicated functional relations expressing the elasto-plastic state of the shell, author substitutes the simple hyperbolic-trigonometric functions. The problem leads to a differential equation the solution of which was given by V. Z. Vlasov [*Izv. Akad. Nauk SSSR, Otd. Tekh. Nauk* no. 6, 1949].

As example, author quotes a solution of a cylindrical shell loaded along the generatrix on the part of its circumference $-\frac{1}{4}\pi \leq \beta \leq \frac{1}{4}\pi$. J. Valenta, Czechoslovakia

5472. Vlasov, V. Z., Theory of space vibration of thin-walled bars and shells as well as aerodynamic stability of suspension bridges (in English), 9th Congrès Intern. Mecân. Appl., Univ. Bruxelles, 1957; **7,** 519–526.

Paper quotes generalized dynamical bending-torsion equations for beams, also quotes nonlinear shell equations. Brief comment is made about shallow spherical shells.

K. H. Griffin, England

Buckling

5473. Becker, H., General instability of stiffened cylinders, *NACA TN* 4237, 22 pp. + 1 table + 2 figs., July 1958.

General instability in moderate-length and long circular cylinders with circumferential and axial stiffening is investigated for the cases of loadings of axial compression, radial pressure, hydrostatic pressure and torsion. Assuming that the spacings of the longitudinal stiffners and the circumferential frames are small enough to consider the cylinder to act as an uniform orthotropic shell, author analyzes the problem generally, extending Taylor's eighth-order partial differential equation obtained for axially loaded orthotropic circular cylinders to the more general form in which the effects of shear and circumferential normal stress are also included. But Taylor's assumption of zero value for Poisson's ratio is retained. Explicit expressions for buckling stresses in various cases are derived, applying the general differential equation to each case and using the energy approach. The results are discussed and compared to the known solutions. Many good agreements are shown. T. Udoguchi, USA

5474. Masur, E. F., On the analysis of buckled plates, Proc. Third U. S. Nat. Congr. Appl. Mech., June 1958; Amer. Soc. Mech. Engrs., 1958, 411–417.

A new approach for the solution of von Kármán's equations governing the postbuckling behavior of plates is presented. Procedure, starting from an assumed stress field, formulates a sequence of trial stress fields; each approximation is obtained from the previous one, approaching correct solutions with increasing accuracy. Method is based on a new minimum principle for the strain energy of membrane stresses, similar in content to that known from the theory of elastic-plastic media. Advantage of proposed approach is the possibility of an error estimate by means of upper and lower bound principles.

Method is applicable throughout the postbuckling domain. Numerical example is solved for the case of a simply supported circular plate subjected to uniform radial pressure; the second trial leads to a satisfactory result. O. Halasz, Hungary

5475. Borsch-Supan, W., Buckling calculations on the Swedish computer BESK (in German), 9th Congrès Intern. Mecân. Appl., Univ. Bruxelles, 1957; **7,** 83–88.

Problem of buckling strength of stiffened rectangular plates under edge compression and shear is treated as variational and solved by double Fourier series. Computer BESK gives the buckling load, using Wielandt's "broken iteration" method [H. Wielandt, Bericht B.44/J/37 Aerod. Versuchsanst. Göttingen 1944] when approximate value is known. Higher eigenvalues may be obtained too. Following conditions were assumed: constant shear with linearly varying compressive load; plate simply supported; maximum of one transversal and two longitudinal stiffeners. Accuracy is determined by maximum of 28 Fourier terms. About 140 eigenvalues were computed and gathered in tables and graphs. They are of great practical importance especially in connection with bridge constructions. M. Zyczkowski, Poland

5476. Langhaar, H. L., and Boresi, A. P., Snap-through and post-buckling behavior of cylindrical shells under the action of external pressure, *Univ. Ill. Engng. Exp. Sta. Bull.* no. 443, 33 pp. + 22 tables, 1957.

Paper is concerned with buckling under combined radial pressure and axial load. Each component of displacement is defined as a Fourier series in circumferential direction with coefficients varying axially. Series are ended at third terms and first coefficient of radial displacement is assumed to be a half sine wave axially. Stresses are evaluated using up to second-order terms in displacements. Kinematic conditions eliminate some of the other coeffi-

cients, and the rest are obtained by minimization of the total potential energy.

Finally, the increment of total energy due to buckling is obtained as a cubic in the square of the buckle amplitude. Tables are presented of values of constants in these expressions in the case of cylinders whose ends are allowed to warp. Modifications in algebra, but no numerical values, are presented for rigid-end case.

Paper shows how energy-displacement relations thus obtained (for differing values of external pressure) may be used to obtain pressure displacement relations. In particular, evaluation of the Tsien critical pressure is demonstrated and recommended as the buckling criterion.

Numerical examples are given for two cases, and curves of buckling coefficient against cylinder aspect ratio are plotted for two values of thickness-radius ratio for both infinitesimal theory and that of paper. Comparison is made with the von Mises theory and discrepancies arise for short thick shells. A brief discussion of the effect of imperfections is made. There is a trivial misprint in Eq. [23]. K. H. Griffin, England

5477. Darevskii, V. M., Stability of a cylindrical shell under simultaneous action of twisting moments and normal pressure (in Russian), *Izv. Akad. Nauk SSSR, Otd. Tekh. Nauk* no. 11, 137–147, 1957.

Author investigates perfectly elastic thin shells "of medium length." The twisting moment M and normal pressure q are assumed to have increased to the critical values $\lambda_{cr} M$, $\lambda_{cr} q$ in such a manner that their ratio remained constant. The critical factor of enlargement λ_{cr} is shown to be an eigenvalue of an associated boundary-value problem for a system of three partial differential equations. The approximative solution—components of displacement—is as usual taken as the first two terms of a trigonometric series in two variables. The eigenvalues are determined graphically. The resulting graph shows the critical values of simultaneously acting loads, and has been verified by 33 experiments with duraluminium and steel shells. An amount of space is devoted to prove that the resulting graph is practically trustworthy for all shells of medium length.

A simple approximative formula for λ_{cr} is derived for the case of sufficiently large ratios of internal pressure to twisting moment. Reviewer believes that the main contribution of this paper is contained in the just-mentioned case of high internal pressure, and in the ingenious graphical method.

I. Hlavacek, Czechoslovakia

5478. Palotas, L., Buckling analysis of reinforced-concrete frame structures, Scientific Publ. of the Tech. Univ. Arch., Bldg., Civil Transport Engng. (Epitoipari es Kozlekedesi Muszaki Egyetem Tudomanyos Kozlemenyei), Budapest, 1957, 13–27.

Paper presents three approximate methods for determining critical loads of rigid-jointed frames with particular reference to frames of reinforced concrete. In the first method, rotational end-restraints provided to critical members by adjoining members are estimated in terms of flexural stiffnesses and carry-over factors of these members. Effective length of critical member is then calculated approximately through use of the end-restraint factors. The second method considers entire frame and requires computation of transverse displacement resulting from unit lateral load. Unit lateral load is applied at joint if sidesway is assumed to be involved in buckling mode, or at or near point of maximum deflection of critical member if sidesway is not involved. The deflection due to unit load is also computed assuming that joints are locked against rotation. Since effective length is known in the latter case, comparison of lateral displacements in two cases provides means of estimating effective length in actual case.

In the third method, approximate buckling mode of frame is obtained by starting with a system of hinged bars, then restoring continuity. Critical loading corresponding to approximate mode is calculated by application of energy method.

J. E. Goldberg, USA

5479. Hoff, N. J., A survey of the theories of creep buckling, Proc. Third U. S. Nat. Congr. Appl. Mech., June 1958; Amer. Soc. Mech. Engrs., 1958, 29–49.

Classical criteria of stability must be abandoned in the presence of nonlinear creep: the concept of critical time must be introduced. After discussing diverse expressions which have been proposed to describe creep, author introduces a mechanical model consisting of a rigid bar, pivoted at the lower end and inclined at angle ϕ, and supported at the other by a horizontal spring and dashpot in series. A vertical load acts at the upper end of the bar. With the help of this model, linear viscoelastic, strain-hardening, reversed creep, and nonlinear viscoelastic columns are discussed. The distinction in buckling theory between the assumption of an ideal column in which buckling is initiated by disturbing the equilibrium configuration, and that of an initially imperfect column, is pointed out. With the latter, a critical deflection can be established from the instantaneous stress-strain curve without regard to creep properties of the material. This approach to computation of a critical time is preferred by Hoff.

Creep buckling criteria for plates and shells is relatively undeveloped because of a lack of information on multi-axial creep laws. Some recent work in this field is discussed briefly.

A. D. Topping, USA

Vibrations of Solids

(See also Rev. 5377)

5480. Huang, T. C., Effect of rotatory inertia and shear on the vibration of beams treated by the approximate methods of Ritz and Galerkin, Proc. Third U. S. Nat. Congr. Appl. Mech., June 1958; Amer. Soc. Mech. Engrs., 1958, 189–194.

Author solves for the frequencies of a vibrating beam (in which shear and rotary inertia effects are included) using the Rayleigh-Ritz method. By considering a particular case, the hinged beam, it is shown that Galerkin's method gives the identical result as that obtained by Rayleigh-Ritz if the same deflection function is used for both methods. S. F. Borg, USA

5481. Belyaeva, G. M., Application of the theory of excitation to the problem of vibrations of a beam (in Russian), *Vestn. Mosk. In-ta Ser. Matem., Mekhan., Astron., Fiz., Khimii* no. 1, 11–21, 1957; *Ref. Zh. Mekh.* no. 4, 1958, Rev. 4528.

The problem of transverse vibrations of an imponderable beam with concentrated masses is investigated, using the method of the theory of excitations. The basic conception centers on a beam with equal masses disposed equidistantly along its length. The rapid convergence of the method is shown.

V. L. Biderman
Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

5482. Volterra, E., Eigenvibrations of twisted and curved elongated bars (in English), 9th Congrès. Intern. Mécan. Appl., Univ. Bruxelles, 1957; **7,** 279–284.

Author solves this theoretically difficult problem very generally using assumptions ordinary in technical mechanics (for example, "sections normal to bar's axis remain plane"). He uses also influence of shear and of rotatory inertia.

Starting relations are derived by means of the "method of internal constraints" used by author in previous articles for solving bar vibration problems.

Nine equations of motion and nine boundary conditions for unknown components of elastic displacements are derived from Hamilton's principle. Solution for equations of motion which can be approximately gained, for example, by means of perturbation method is not shown in this article.

Reviewer accents generality of solution from which, by means of the corresponding simplifications, the equations of motion can be gained whose different types appear often in the technical practice (twisted bar, curved bar, straight bar) with different boundary conditions. V. Petrovsky, Czechoslovakia

5483. Pukhov, G. E., and Chegolin, P. M., Bringing a vibrating rod system into an electrical circuit composed of tripoles (in Russian), Electric small scale manufacture of beams and frames, Taganrog, 1956, 59-71; *Ref. Zh. Mekh.* no. 4, 1958, Rev. 4524.

The electromagnetic analogy is investigated. The possibility of extending the tripole method to the case of a dynamic rod system is indicated. The following cases are examined: bringing a vibrating imponderable rod with concentrated masses into an electrical tripole system; transverse vibrations of ponderable rod systems, carrying concentrated masses, subjected to arbitrary pulsating forces. Using the electromodelling method, calculations are made for a two-span frame with a pulsating load on one of the spans; the close relationship of the calculations for this case with the data for the calculations for the same frame carried out by known analytical methods is demonstrated. N. I. Bezukhov

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Translation, courtesy Ministry of Supply, England

5484. Hoppmann, W. H., II, Flexural vibration of orthogonally stiffened circular and elliptical plates, Proc. Third U. S. Nat. Congr. Appl. Mech., June 1958; Amer. Soc. Mech. Engrs., 1958, 181-187.

Nodal patterns and frequencies are recorded experimentally for circular and elliptical plates, with and without stiffeners, clamped at boundaries. Equations are developed for orthotropic plates as analagous to stiffening. A few calculated frequencies are recorded. R. N. Arnold, Scotland

5485. Jullien, Y., Vibration of rectangular plates supported at the edges and loaded with a concentrated force, (in French), *C. R. Acad. Sci. Paris* **246,** 9, 1371-1374, Mar. 1958.

Author generalizes to plates his own method employed for the analysis of vibrations in beams submitted to discontinuous loads [*J. Phys. Rad.* **16,** pp. 107-108, 1955]. It consists in a fictive prolongation of the real beam through fictive congruent beams, developing the mass by simple Fourier series and taking fictive loads when the period is not consistent with the length of the real beam.

For the plate he uses the known differential equation $\nabla^2\nabla^2 w - \alpha^2 w = 0$, expands the load by a double cosine series and obtains the ultimate equation of eigenvalues for the frequencies, with simple supported boundaries. Finally he analyzes the cases of a square plate with a central load, a load at the quarter, null or infinite load. A. M. Guzman, Argentina

5486. Chang, C. S., Energy dissipation in longitudinal vibration, Proc. Third U. S. Nat. Congr. Appl. Mech., June 1958; Amer. Soc. Mech. Engrs., 1958, 109-116.

By means of the Mindlin-Goodman method in which a vibration problem is split into two parts, one of which is the steady-state solution and the other the solution of a free vibration problem, author solves the problem of longitudinal forced vibration of a finite bar terminated with a viscous damper. Step-by-step details of the solution are presented. Solutions are given for both periodic and nonperiodic excitation of the bar. It is shown that, by choosing the damping coefficient such that the force required to move the dashpot at the velocity of wave propagation in the bar is just equal to the total force at any section of the bar for a unit strain, no reflections will occur. All energy arriving at the dashpot end of the bar is absorbed by the damper. This appears to be true whether excitation of the bar is periodic or nonperiodic. Since the analysis is based on the elementary theory of wave propagation in bars in which it is assumed that all wavelengths are propagated at the same velocity, it appears that in a bar suitably terminated by a dashpot those pulses which will propagate without appreciable dispersion will be completely absorbed in the dashpot. Thus by proper termination a finite bar can be made to appear as a semi-infinite bar to nondispersed pulses. This will be an intriguing possibility to Hopkinson pressure bar users.

E. A. Ripperger, USA

5487. Skowronski, J., A method of qualitative analysis of vibrating discrete systems with strong nonlinearity in the phase space (in English), *Arch. Mech. Stos.* **10,** 5, 714-726, 1958.

Paper concerns the qualitative investigation of dynamic non-autonomous systems, showing pronounced nonlinearity, having n-degrees of freedom and any coupling. The investigation of the trajectory is done in the $2n$-dimensional phase space. The method used constitutes a geometrical interpretation of the known "delta" method. A method is proposed for constructing the projections of the phase trajectory on the projection planes of which the total number is equal to that of the degrees of freedom of the system considered. The qualitative image of the behavior of the phase trajectory is obtained by introducing the "delta" vector and considering its hodograph. In conclusion the notion of hard and soft characteristic is generalized for a certain variable.

K. Piszczek, Poland

5488. Nazarov, A. G., Investigation of internal friction during elastic vibrations (in Russian), Trudĭ Koordinats. Soveshchaniya Poseismostoik. Str-vu, 1954, Erevan, Akad. Nauk ArmSSR, 1956, 131-148; *Ref. Zh. Mekh.* no. 11, 1957, Rev. 13122.

A concise exposition is given of results obtained by the author when analyzing questions on the dissipation of energy in conditions of nonstationary vibrations, and also in a complex stressed state. The possibilities are indicated of applying the correlations obtained for the creation of a theory of stability against seismic action and for the construction of seismic meters, simulating the vibrations of installations during earthquakes.

D. M. Vasil'ev

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5489. Salles, F., Behavior of an oscillating system under the effect of a constant force which is established by degrees (in French), 9th Congrès Intern. Mécan. Appl., Univ. Bruxelles, 1957; **7,** 216-224.

Paper discusses the effect on a vibrating system of the manner in which a disturbing force is built-up from zero to a constant value. Experimental evidence is shown. E. Saibel, USA

5490. Fujino, T., A theoretical consideration on the vibration of turbine blade system, *Bull. JSME* **1,** 2, 119-123, June 1958.

Classical analysis uses Lagrange's equation of "fixed-free" and "fixed-supported" vibration of a group of shrouded, nontwisted turbine buckets. Because of simplifying assumptions its interesting results are not directly applicable to general bucket design. Nevertheless, they reveal that for certain ratios of bucket to nozzle pitch and number of buckets per shroud group the "fixed-free" (fundamental) response is suppressed, while that of the "fixed-supported" (sometimes called second-type tangential) may range from zero to three times that of a single "fixed-supported" bucket. These results are known to major American turbine manufacturers.

Paper is difficult to understand and contains errors. Nomenclature is ill-defined and confusing. J. E. Corr, USA

5491. Stanisic, M. M., On the eigenvector direction of turbine blades with lashing wire (in English), 9th Congrès Intern. Mécan. Appl., Univ. Bruxelles, 1957; **7**, 249–260.

A method is demonstrated to find the direction of the eigenvector for the first mode of vibration of turbine blades interconnected with lashing wire. The method, which can be applied also to cases of more than one interconnection, is based on the principle that during vibration the energy stored in the system is a minimum. As an illustration of procedure a detailed solution is worked out. The results show that in the case of one interconnection with a lashing wire, the direction of the eigenvector almost coincides with the direction of the axis of maximum moment of inertia.

From author's summary by M. S. Weinstein, USA

5492. Sohngen, H., and Quick, A. W., Vibrations in compressors (in German), C. R. Journées Internationales de Sciences Aéronautiques, Paris, May 27–29, 1957; Paris, ONERA, Part 1, 119–130.

5493. Sakharov, I. E., On forced vibrations of stators of alternating current electrical machines (in Russian), *Izv. Akad. Nauk SSSR, Otd. Tekh. Nauk* no. 11, 167–169, 1957.

Author makes three assumptions: (1) rotor can be taken as thin ring of constant thickness, (2) the induction in the gap is pure fundamental, (3) external friction force is proportional to rotational speed and internal friction force proportional to strain rate. Kyshyl's relationship [*Akad. Nauk SSSR, Otd. Tekh. Nauk* no. 10, 1954] between stress, strain and strain rate is used to include the effects of internal friction into Love's equilibrium equations for a thin ring of constant thickness. This yields a partial differential equation in which a seventh-order term appears but, by assuming the solution to be harmonic and of double-frequency, constants are evaluated without difficulty, but are complicated. A generalized expression for dynamic deflection along the axial length of the stator is deduced. There appears to have been no attempt to use the analysis in a numerical case but author states that it confirms, qualitatively, experiments on large turbo generators. The two conclusions regarding frequency and phase are almost trivial.

R. C. Brewer, England

5494. Kashcheev, V. M., Dynamic balancing of rotors by the oscillation method (in Russian), *Izv. Akad. Nauk SSSR, Otd. Tekh. Nauk* no. 2, 51–57, Feb. 1958.

The new theoretical method of balancing rotors, presented in this paper, requires merely simple measurements and easy computations. Theoretical results of the method are in good agreement with a great number of the author's experiments with mechanical models.

The new procedure is based on observing and measuring oscillations of the rotor in question, and the results of this investigation enable the author to deduce a good appraisal both of the dynamic unbalance and of kinetic asymmetry of the rotor. The effect of friction is also taken into account because even quite small frictional moments can essentially influence the resulting oscillations of dynamically unbalanced rotors.

Particularly efficient is the author's method in the case of comparatively small rotors (both as to their weight and their dimensions) having an elongated ellipsoid of inertia. Owing to its simplicity, the new procedure will certainly find much use in technical practice.

V. Vodicka, Czechoslovakia

5495. Abramov, G. D., On the analysis of three-dimensional stability and vibrations of noncircular arches (in Russian), *Izv. Akad. Nauk SSSR, Otd. Tekh. Nauk* no. 4, 110–113, Apr. 1958.

This is a brief description of a method of analysis of critical (buckling) loads and natural frequencies of arches, when displacements perpendicular to their planes are considered. The arch, of arbitrary shape and solid cross section, is replaced by a polygonal system of n bars, each having constant cross section. A system of n linear algebraic equations is derived, with torsional moments in the bars as unknowns, and the effect of axial forces and inertial terms considered. Critical loads and natural frequencies are determined by setting the determinant of the equations equal to zero. Fairly good approximations are obtained with relatively small numbers of bars in the polygon. The paper may be of interest to structural designers.

M. P. Bieniek, USA

5496. Vaserman, E. B., Influence of the behaviour of a load on the frequency of two-dimensional vibrations of a round arch (in Russian), *Uch. Zap. Latv. In-ta* **10**, 81–111, 1957; *Ref. Zh. Mekh.* no. 4, 1958, Rev. 4517.

The problem is investigated of the free vibrations and stability of round unhinged and two-hinged arches, compressed evenly by a distributed radial load. Three cases of the behavior of the load in the process of the deformation of the arch in its own plane are studied. For the unhinged arch exact equations are derived for the frequencies, taking into account the normal forces; from these the equations for the critical state are obtained. For the unsymmetrical forms of the vibrations Bubnov's method is applied. In this form too is given the solution of the problem regarding the frequencies of the free vibrations and critical load of two-hinged arches. In order to simplify the calculations the equations for the frequencies are transposed in such a way that they contain only the active number. The results of the approximate and exact solutions are compared in numerical examples.

D. V. Vainberg

Courtesy Referativnyi Zhurnal, USSR

Translation, courtesy Ministry of Supply, England

5497. Dol'berg, M. D., Bonds of maximum rigidity (in Russian), *Uch. Zap. Khar'kovsk. In-ta*, 1957, **80**, (*Zap: Mat. Otd. Fiz. Mat. Fak. i Khar'kovsk. Mat. O-va* **25**, 179–190); *Ref. Zh. Mekh.* no. 4, 1958, Rev. 4527.

This is a problem concerning the search for conditions guaranteeing the maximum increase of the basic frequency of a rod system by means of the addition of complementary bonds (the extended investigation of I. G. Bubnov: "Constructional mechanics of the ship," Vol. 1, 1912). Assuming the number of bonds to be known, author uses the variational principle to solve the problem. To obtain the solution it is essential to determine the maximum-minimum values of some functional conforming to the given conditions. The connection of the problem with R. Courant theorem [R. Courant, D. Hil'bert: "Methods used in mathematical physics," Vol. 1, 1951] is noted. Author's analysis is based on the properties of the nuclei of the integral equations of the problem regarding the vibrations of elastic rod systems. The question is investigated in detail for the increase of the first frequency of the beam's vibrations.

I. S. Arzhanykh

Courtesy Referativnyi Zhurnal, USSR

Translation, courtesy Ministry of Supply, England

5498. Bycroft, G. N., Machine foundation vibration, Instn. Mech. Engrs., Prepr., 5 pp., 1958.

5499. Tobias, S. A., The vibrations of vertical milling machines under test and working conditions, Instn. Mech. Engrs., Prepr., 20 pp., 1958.

5500. Chuvikovskii, V. S., Calculations for the forced vibrations of a hull's sheath (in Russian), *Sudostroenie* no. 9, 16–18, 1957; *Ref. Zh. Mekh.* no. 4, 1958, Rev. 4702.

Some general relations are put forward which permit carrying out the determination of the amplitude of the forced vibrations of a peculiar form of the covering, made up of a large number of identical equally spaced prismatic main beams with a few intersecting cross components of variable rigidity. The ends of the beams, main and secondary, are taken to be fastened in arbitrary fashion. Cases

are examined when external loads were periodically applied both to the cross beams and the main beams. It is shown how to carry out the calculation for the dissipation of energy when investigating near-resonant states. N. N. Babaev

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

5501. Ifrim, M., Direct calculation of the natural frequency of vibration for buildings subjected to earthquakes (in Roumanian), *Studii Si Cercetari Mecan. Appl.* **10**, 1, 211–217, 1959.

In order to define the physical properties and the dynamic rigidity of structures subjected to strong-motion earthquakes, author presents explicit relations for calculating the natural frequency of vibration of shear buildings.

The relation given for fundamental frequency leads to values whose approximation is below one per cent as compared to those obtained through exact methods. The formula proposed for high frequencies gives more accurate results that those given by other similar relations.

Reviewer believes paper is worth noting for the simplicity of the proposed formulas and the good approximation of the results.

M. Soare, Roumania

5502. Goldberg, J. E., Bogdanoff, J. L., and Moh, Z. L., Forced vibration and natural frequencies of tall building frames, *Bull. Seismol. Soc. Amer.* **49**, 1, 33–47, Jan. 1959.

Assuming masses to be concentrated at floor levels and rotations of all joints at a given level to be equal, a procedure based on the use of slope deflection equations is presented for obtaining the natural modes and frequencies, or the response to harmonic motion of the ground, of tall building frames. Numerical computations for the modes and frequencies of a ten-story frame are carried out with a desk computer. F. L. DiMaggio, USA

5503. Jullien, Y., Vibrations of a simple frame driven into an elastic subgrade (in French), 9th Congrès Intern. Mécan. Appl., Univ. Bruxelles, 1957; **7**, 419–433.

Paper treats interesting problem of free vibrations of simple elastic frame which consists of a girder and two columns, rests on an elastic subgrade, and supports a concentrated mass placed at the center of the girder. The usual linear relationship between reaction of elastic subgrade and deflection is assumed to exist. The columns are subjected only to horizontal reactions from the subgrade. The natural frequencies and corresponding natural modes are derived through an application of Fourier series. The experimental results of a small model, composed of a duraluminum frame and a rubber mat simulating the elastic subgrade, substantiated reasonably well the predictions of the analysis.

A. W. Coutris, USA

5504. Smola, P., Simplified analysis of vibrations of continuous frame structures (in Czech.), *Stavebnicky Casopis* **5**, 3, 167–197, 1957.

5505. Warburton, G. B., Forced vibration of a body on a stratum of soil (in English), 9th Congrès Intern. Mecán. Appl., Univ. Bruxelles, 1957; **7**, 137–142.

5506. Slotin, V. I., and Eskin, G. I., On the effect of ultrasonic vibrations on the primary crystallization of aluminum alloys (in Russian), *Izv. Akad. Nauk SSSR, Otd. Tekh. Nauk* no. 9, 33–36, Sept. 1957.

Data were obtained on the mechanical properties and structural changes of a cast high-strength aluminum alloy containing in weight 2.0% Cu, 0.8% Mg, 2.5% Si, 1.0% Ni, 1.0% Fe, 0.3% Ti, balance Al. A piezo-quartz technique was used. An ultrasonic vibrator built on the base of a high-frequency generator (power 100 watts, frequency 800 kc/sec) transmitted vibrations to a 100-gram casting held in a plaster mold.

Ultrasonic treatment hastened the process of solidification leading to a finer macro- and microstructure. The mechanical properties improved, the tensile strength and hardness increasing more then the elongation both in the as-solidified and the heat-treated state, e.g., tensile strength of 22.4 kg/mm² for alloy with ultrasonic treatment versus 17.3 kg/mm² for alloy without treatment in the as-cast condition; 33.5 kg/mm² for alloy with ultrasonic treatment versus 26.3 kg/mm² for alloy without treatment in the heat-treated condition. Anna M. Turkalo, USA

5507. Nothen, J., Vertical and pitching oscillations of two-axled railway car initiated by track irregularity (in German), *Tech. Mitt. Krupp.* **16**, 5, 116–152, Dec. 1958.

Author presents elaborate and out-of-date style calculation to title case. Track irregularity is assumed to involve both rails symmetrically. Rail (ground) flexibility is taken into account. Numerical applications are given.

J. H. Greidanus, Holland

5508. Bergmann, L., A thermo-optical method for the indication and measurement of mechanical vibration (in German), *Z. Naturforsch.* **13a**, 8, 499–602, Aug. 1958.

Author describes in detail an optical system for detecting small angular vibrations and a novel system for exciting resonant vibrations by the intermittent application of heat. The optical detection system consists of a light source, several lenses, two transparent parallel line gratings, a mirror attached to the vibrating body, and a sensitive photocell, which are so arranged that the vibration causes a change in intensity of the light falling on the photocell and hence a change in the current delivered by the cell and indicated with a microammeter. The vibration exciter consists of a rotating disk with perforations to interrupt a beam of light focused on a black spot on the specimen. A resonant vibration of small amplitude tends to build up if the frequency of the heating of the black spot caused by the intermittent beam of light coincides with a natural frequency of the body. Author emphasizes advantages of method over other methods of exciting vibrations and illustrates it by applications to tuning forks and helical springs. Possibilities of method for measuring radiation pressure are indicated.

W. Ramberg, USA

5509. Ivanov, M. N., A photo-skiagraph method for recording oscillations (in Russian), Mashiny i pribory, Moscow, Mashgiz, 25–32, 1953; *Ref. Zh. Mekh.* no. 2, 1958, Rev. 1571.

A description of the inertialess instrument MVTU-IM-IV, for the direct recording of various forms of motion. The record is made on a photographic film by means of a ray of light. The instrument has three recorders (time, rpm, etc.) and can record displacements in three different planes simultaneously. The film speed is controllable between 0.3–1.5 m/sec. Photo-skiagraphs with records of some cases of motion are appended. K. S. Kopesnikov

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

5510. Bouche, R. R., Mechanical vibration standards of the electrodynamic type (in English), 9th Congrès Intern. Mecán. Appl., Univ. Bruxelles, 1957; **7**, 395–406.

5511. Arnold, R. N., Response of an impact vibration absorber to forced vibration (in English), 9th Congrès Intern. Mécan. Appl., Univ. Bruxelles, 1957; **7**, 407–418.

A frictionless mass, free to oscillate within a container affixed to a single-degree-of-freedom system of resonant frequency p, is investigated as a means of absorbing vibration. Although the experimental results do not agree with theoretical predictions the

evidence indicates that this might be a useful device for absorption of vibration in the region about the frequency p.

M. S. Weinstein, USA

5512. Bernstein, B., Hall, D. A., and Trent, H. M., On the dynamics of a bull whip, *J. Acoust. Soc. Amer.* **30,** 12, 1112–1115, Dec. 1958.

Combining the skills of the Los Larabees whip-cracking team with electronic and photographic equipment, very excellent pictures of shock waves produced at the tip of a bull whip are shown. In addition, high-speed movies of the motion of the tip of the whip indicate velocities of the tip of about 1400 fps.

The equations for the motion of the whip, similar to those of the vibrating string, are set up. Not being able to find a continuous solution, author assumed that a discontinuity in tension propagates down the whip. The solution for this simplified motion gives the qualitative result that the free end of the whip and the tension increase without limit toward the tip of the whip.

From this paper the conclusion can be drawn that the cracking sound of a whip or whip-like instrument results from supersonic motion of the whip tip rather than the whip slapping itself.

K. Schneider, USA

Wave Motion and Impact in Solids

(See also Rev. 5695)

5513. Zachmanoglou, E. C., and Volterra, E., An engineering theory of longitudinal wave propagation in cylindrical elastic rods, Proc. Third U. S. Nat. Congr. Appl. Mech., June 1958; Amer. Soc. Mech. Engrs., 1958, 239–245.

A one-dimensional theory of longitudinal wave propagation in cylindrical elastic rods is presented. This theory, which represents an improvement over a previous theory, both of which are based on the method of internal constraints, takes into account second-order terms in the equation of constraints and brings to an engineering level the otherwise complicated numerical work involved in the exact theory. Numerical results obtained by the use of this theory are compared with those obtained by the exact theory. From authors' summary

5514. Sveklo, V. A., and Siukiiainen, V. A., Diffraction of a plane elastic wave at the vertex of a sector, *Soviet Phys.-Doklady* **3,** 2, 451–452, Dec. 1958. (Translation of *Doklady Akad. Nauk SSSR (N. S.)* **119,** 6, 1122–1123, Mar.–Apr. 1958 by Amer. Inst. Phys., Inc., New York, N. Y.)

5515. Barton, C. S., Volterra, E. G., and Citron, S. J., On elastic impacts of spheres on long rods, Proc. Third U. S. Nat. Congr. Appl. Mech., June 1958; Amer. Soc. Mech. Engrs., 1958, 89–94.

Horizontal impact of 1 to 2-in. steel balls on long 1-in. diameter steel bar is investigated experimentally. Characteristics of strain pulse show close agreement with calculations based on Hertz's theory. Measuring equipment is described.

R. N. Arnold, Scotland

5516. Goldsmith, W., and Norris, G. W., Jr., Stresses in curved beams due to transverse impact, Proc. Third U. S. Nat. Congr. Appl. Mech., June 1958; Amer. Soc. Mech. Engrs., 1958, 153–162.

A sequence of photoelastic fringe patterns in curved and cantilever beams has been obtained by repeating the impact of a sphere on the free end of these bars and photographing the event at known time intervals. Some of the stress histories determined in this manner have been compared with corresponding strain-gage results and analytical predictions. Static and dynamic values of the stress-optic coefficient and the modulus of elasticity are determined for CR-39, and the maximum values of the experimentally determined stresses for both static and dynamic loading conditions on a bent, a quarter circle, and a cantilever beam consisting of this material are compared. From authors' summary

5517. Kil'chevskii, N. A., Determination of dynamic stresses appearing as the result of torsion in round rods of variable section (in Russian), *Izv. Kievsk. Politekhn. In-ta* **19,** 252–268, 1956; *Ref. Zh. Mekh.* no. 4, 1958, Rev. 4529.

The dynamic stresses are investigated for round bars described in the title. The problem leads to the solution of some functional equation brought into Fredholm's integral equation of the second order. Exact and simplified integral equations are derived for the problem, the author making use of Saint-Venant's principle for the simplified equations. The application of the simplified integral equations opens up the possibility of obtaining approximate formulas determining the distribution of stresses and strains in rods of variable section. M. M. Manukyan

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

5518. Farrar, N. S., Vibration waves in concrete, *Engineer, Lond.* **206,** 5354, 378–380, Sept. 1958.

5519. Dugdale, D. S., Stress-strain cycles of large amplitude, *J. Mech. Phys. Solids* **7,** 2, 135–142, Mar. 1959.

Strain cycles of constant amplitude were imposed on specimens of copper, steel and aluminum alloy while variations in stress amplitude were recorded. For annealed materials the stress increased with successive cycles, but for cold-worked materials it diminished, reaching steady values after definite amounts of plastic strain. These materials became conditioned in various ways by their strain history. From author's summary

5520. Laban, S., Some ways of solving the problem of axial and elastic impact between semi-infinite bars (in French), 9th Congrès Intern. Mécan. Appl., Univ. Bruxelles, 1957; **7,** 175–187.

By elementary one-dimensional analysis of stress wave propagation, author derives Saint-Venant's expression for the transient velocity of compressed portion during axial impact of two straight uniform bars. H. S. Tan, USA

5521. Mori, D., Lateral impact on bars and plates, *Proc. Soc. Exp. Stress Anal.* **15,** 1, 171–178, 1957.

Paper describes tests to show effect of tensile stress in rods and plates on velocity of flexural waves. Theoretical treatment is outlined in appendix; Fourier transform techniques are used and results are plotted for bars and for a plate under pure shear. Experimental set up is described; and results are compared with theory (a) for long bar under varying tension and for short bar under no load, and (b) for the plate under pure shear. Comparison is good. Paper suggests use of results for measurement of loads in cables. Presentation is not entirely clear.

K. H. Griffin, England

5522. Viktorov, I. A., The effects of surface defects on the propagation of Rayleigh waves, *Soviet Phys.-Doklady* **3,** 2, 304–306, Dec. 1958. (Translation of *Doklady Akad. Nauk SSSR (N. S.)* **119,** 3, Mar.–Apr. 1958 by Amer. Inst. Phys., Inc., New York, N. Y.)

5523. Roseau, M., Diffraction of elastic waves in a homogeneous medium clamped along a half-plane, *Comm. Pure Appl. Math.* **12,** 1, 67–85, Feb. 1959.

Paper is a solely mathematical investigation of the stated problem which is shown to be reducible to the solution of a pair of integral equations of Wiener-Hopf type. Solution is obtained by means of Fourier transforms.

Since neither graphs nor numerical examples of the solution are offered, reviewer believes paper has very limited immediate interest except to mathematicians.

M. J. P. Musgrave, England

5524. Bodner, S. R., and Kolsky, H., Stress wave propagation in lead, Proc. Third U. S. Nat. Congr. Appl. Mech., June 1958; Amer. Soc. Mech. Engrs., 1958, 495–501.

The mechanical behavior of pure lead bars is investigated by sinusoidal vibrations and by propagation of large amplitude stress pulses. The sinusoidal vibrations show that the damping in lead is independent of frequency. Damping increases with increasing strain amplitude. The modulus of elasticity was found to increase slightly with frequency and to be independent of strain amplitude. Results are compared to viscoelastic behavior.

Stress-propagation experiments gave results in good agreement with vibration tests. Fourier synthesis for lead gives predictions which approximate experimental observations when stress amplitudes are low. Experiments with large amplitude pulses show the dynamic yield stress is far in excess of static yield stress.

R. E. Graham, USA

5525. Mochalov, S. D., The question of propagation of elastic-plastic waves along a rod with variable limits of elasticity (in Russian), *Uch. Zap. Tomskogo In-ta* no. 25, 49–67, 1955; *Ref. Zh. Mekh.* no. 4, 1958, Rev. 4570.

This is an investigation of a longitudinal impact along the face of a semi-infinite rod, causing elastic-plastic deformation. The elastic limit of the rod is taken to be inconstant, decreasing or increasing with the modulus in the direction of propagation of the wave. The difference from the work of Kh. A. Rakhmatulin [*Prikl. Mat. Mekh.* **14,** no. 1, 1950] lies in the selection of dependence of stress σ on deformation ε. It is assumed that all the special characteristics of the dependence $\sigma - \varepsilon$, when loaded statically and when unloaded, are preserved even during impact disturbance; the solution is made by the method of characteristics. This point of view is generally accepted in those cases when the static curve $\sigma - \varepsilon$ is replaced by one dynamic curve. Lee's work [E. H. Lee, *Quart. Appl. Math.* **10,** 4, 335–346, 1953; AMR **6** (1953), Rev. 2177] in which the propagation of elastic-plastic waves in a short rod is examined overlaps the author's work in some of its parts. A somewhat different approach to the solution of the problem and different results (in the case of the propagation of the wave in the direction of diminution of the elastic limit) were obtained by the abstractor [*Prikl. Mat. Mekh.* **18,** no. 2, 1954; AMR **8** (1955), Rev. 2641].

N. F. Lebedev

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

5526. Nezhentsev, P. I., Determination of dynamic deflections, taking into account elastic-plastic deformations at the point of contact (in Russian), *Trudi Nikolaevskogo, Korable'stroit. In-ta* no. 8, 211–218, 1956; *Ref. Zh. Mekh.* no. 4, 1958, Rev. 4573.

The problem is investigated of the impact of a load on a beam, taking into account the elastic-plastic deformations at the point of contact. When solving the problem use is made of the method proposed by N. N. Davidenkov [*Sb. Trudi In-ta Stroit. Mekh., Akad. Nauk USSR* no. 11, 1949] the beam is replaced by an elastic system with one step of freedom; a linear relationship is assumed between the local deformation at the point of contact and the force appearing on impact. Only the maximum deflection of the beam and the biggest local deformation are determined; the subsequent process of the impact is not investigated. The magnitudes of the dynamic deflections, obtained by experiment and by calculation, are furnished for three different beams with four different cases of support reinforcement.

Yu. A. Rakovshchik

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

5527. Bell, J. F., Propagation of plastic waves in solids, *J. Appl. Phys.* **30,** 2, 196–201, Feb. 1959.

Using his method [AMR **10** (1957), Rev. 668] for the determination of plastic strain in solids by measuring the angle of diffraction gratings ruled directly on the specimen surface, author presents some results of the application of this technique to the case of axial impact in annealed aluminum cylindrical rods. Strain-time response obtained at three distances from the impact end shows proportionality between propagation time of each level of strain and the distance from impact (verification of the strain-rate independent theory); this enables a dynamic determination of Poisson's ratio as a function of strain from the time-history data of strain and surface angle at one distance from the impact end. Marked changes in the propagation behavior observed above 1.06% strain are related to the abrupt increase of Poisson's ratio at this critical value of strain.

F. Krupka, Czechoslovakia

5528. Konishi, I., Yamada, Y., Shinozuka, M., and Kobori, T., Stochastic study of coefficient of impact in design of highway bridge (in Japanese), *Trans. Japan Soc. Civ. Engrs.* no. 62, 1–5, May 1959.

Studies of the dynamic behavior of a bridge under several pulsating forces indicate that the resultant vibration is a combination of each individual vibration. The phase differences of the fundamental vibrations have a certain influence upon the resultant oscillation of the bridge. In the present paper, authors consider that these phase differences occur at random under the various traffic conditions and they stochastically clarify that the values of the impact coefficients are reduced successively according to the loading length.

From authors' summary

Courtesy, Editorial Committee of the Japan Society of Civil Engineers

5529. Hruban, I., and Vitek, B., The effect of shocks on hydraulic structures in the earthquake regions of Slovakia (in Czech.), *Stavebnicky Casopis* **5,** 4, 239–252, 1957.

5530. Terplan, Z., and Drobni, J., Dynamics of simple two-dimensional mechanisms (in Hungarian), *Magyar Tud. Akad. Musz. Tud. Oszt. Köz.* **21,** 1/4, 115–131, 1957.

5531. Bondarev, Yu. E., The work of dynamic deflection (in Russian), *Izv. Vost. Fil. Akad. Nauk SSSR* no. 3, 63–71, 1957; *Ref. Zh. Mekh.* no. 4, 1958, Rev. 4837.

With the help of an analysis of dimensions the relation was established of the magnitude of the work of impact in the dynamic deflection of notched samples to the mechanical properties, determined during the tensioning of smooth samples of the same material. The general conclusions obtained from the analysis were improved by experiments and by selection from the experimental data of the analytical relationships. It was shown that in the conditions of viscous disintegration the impact viscosity A_k is linked with the mechanical properties, determined during tensioning

$$A_k = D_1 bh^2 \sigma_B \psi_k$$

where D_1 is the function of the magnitude of even deformation during the tension of a smooth sample (a calculation curve for the function is given), σ_B is the limit of stability, ψ_k is the full shrinkage of the area of the transverse section of the disrupted sample, b and h are the width and height of the field of fracture of the sample during deflection. The formula is confirmed by comparative data for samples of seven different types of steel. Divergence did not exceed the limits of -16 to $+9\%$. A deduction is

advanced regarding the possibility of cutting down the impact experiments at normal temperatures for those steels in which the possibility of the occurrence of brittleness due to tempering can be ruled out. It is shown that for brittle fracture the correlationship given is unsuitable. P. O. Pashkov

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

5532. Prigorovskii, N. I., and Mazitov, Sh. S., Procedure and apparatus for the experimental investigation of stresses and forces when components of a machine are in mutual impact (in Russian), *Izv. Otd. Estestv. Nauk, Akad. Nauk TadzhSSR* **15,** 25–51, 1956; *Ref. Zh. Mekh.* no. 3, 1958, Rev. 3482.

An investigation of the phenomenon of impact, observed with the aid of wire strain gages and a specialized two-ray cathode-oscillographic apparatus, enabling the recording of deformations of 0.1–3% at frequencies of 35–25,000 Hertz to be accomplished. The experiments are described and comparisons are given for four different cases of impact, for which solutions are available by other authors: (1) transverse impact of a load on a beam and ring made of optically active material; (2) longitudinal impact of two steel rods; and (3) transverse impact of a load along a steel I-beam. V. N. Maksimov

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

Soil Mechanics: Fundamental

(See also Revs. 5447, 5505, 5599)

5533. Troitskaya, M. N., Stability of soils and a method for determining shear resistance (in Russian), Trans. of the Council for Engng.-Geol. Properties of Rock Strata and Methods for Their Study, Moscow, 1957, 99–105; *Ref. Zh. Mekh.* no. 3, 1958, Rev. 3292.

Results are given of the experiments for determining the shear resistance of clays and argillaceous soils, carried out in the laboratory of soil mechanics MGU on a single-plane apparatus at normal pressures of from 0 to 18 kg/cm^2. The appreciable range of normal pressures used permitted the establishment of the curvolinearity of the curve of dependence of the shearing stress to the normal. Author holds the view that the obtained curve can be divided into three, and when using a large range of normal pressures into four, portions. On the first two portions the curve form approaches that of a hyperbola; on the second portion it is possible to look upon the shearing stress as approximately constant. The transition to the third portion of the shear curve is accompanied by the disruption of the natural structure of the soil, by the shrinking and increase of shear resistance. In the fourth portion the curve has again an asymptote, corresponding to the limit of full resistance of the soil after disruption of the structure.

The testing of samples of soil of natural structure for shear, in those cases when the saturation of the soil with water in natural conditions is not assumed, is recommended to be carried out without preliminary compacting and with compacting, using a stopping device. Attention is called to the fact that the normal pressure during shear should correspond to the pressure created by the weight of the installation and the soil's specific gravity.

V. G. Berezantsev

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

5534. Berezantsev, V. G., Calculation of the stability of sandy slopes by the method of the theory of equilibrium limits (in Russian), *Trudi Vses. N.-i. In-ta Transport. Str-va* no. 18, 32–52, 1956; *Ref. Zh. Mekh.* no. 4, 1958, Rev. 4589.

An approximate solution is given of the problem on the stability of a rectilinear slope, which was solved by V. V. Sokolovskii [*Prikl. Mat. Mekh.* **15,** no. 6, 1951]. The essence of the approximate solution lies in the fact that the lines of slip are replaced by circles. An evaluation is furnished for the factor of safety of the slope's stability. A. M. Kochetkov

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

5535. Kruglov, I. N., New automechanized appliances for the determination of compression in soils by static loading (in Russian), Trudí Soveshehaniya po Inzh.-Geol. Svoistvam Gorn. Porod i Metodam ikh Izucheniya, Moscow, 1957, 254–263; *Ref. Zh. Mekh.* no. 4, 1958, Rev. 4619.

Two new automatic appliances are described for the static testing of soil in cylinders with a depth of 1.5–1.8 m. The set-up of the appliances is described and a brief outline of their features. The tests were carried out in field conditions.

S. A. Roza

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

5536. Archashnikov, V. P., Regarding a single problem in the theory of the limit of equilibrium (in Russian), *Izv. Akad. Nauk KazSSR, Ser. Matem. i Mekhan.* no. 5 (9), 109–115, 1956; *Ref. Zh. Mekh.* no. 3, 1958, Rev. 3278.

An approximate method is utilized for the solution of the following known plane problem on the stability of foundations: along the negative semi-axis x, exhibiting rectilinear features to the horizontal boundary of the ponderable soil, constant pressure is assumed; the minimum pressure along the positive semi-axis x has to be found. To obtain an approximate analytical solution, author, on the basis of the analysis of solved problems of similar type, both for the case of an unweighable and a weighable medium, sets himself the task of delineating the lines of slip of one of the families. For axially symmetrical problems this method was proposed by V. G. Berezantsev ["Axially symmetrical problem of the theory of the limit of equilibrium of a friable medium," Moscow, Gostekhizdat, 1952]. The question is not raised regarding the evaluation of the error possible in the solution. G. S. Shapiro

Courtesy Referativnyi Zhurnal, USSR
Translation, Courtesy Ministry of Supply, England

5537. Bekker, M. G., A definition of soil trafficability, Ordnance Corps, Land Locomotion Res. Branch, Res. & Develop. Div., OTAC Rep. 41, 32 pp., June 1958.

When vehicle applies vertical force to ground of less than ultimate bearing capacity, its tractive effort is essentially due to large-scale surface shear test on soil. As the ultimate bearing capacity is approached, tractive effort reaches a peak, then rapidly falls to zero. Paper attempts to define soil trafficability in terms of thrust/load ratio, analogous to lift/drag ratio of fluid. Four vehicle tests on snow and soil show actual performance less than calculated, particularly near peak tractive effort, presumably due to slip between track and ground.

Reviewer feels that value of paper would be greatly enhanced by precise and complete description of soil properties and test techniques used to obtain strengths. For example, "muddy soil," even with c and ϕ values, means very little. Calculation of ultimate bearing capacity values would give rational basis to author's proposed definition. Reviewer feels great potential value of paper could be thereby realized, and hopes further work will be done in that direction. T. K. Chaplin, England

5538. Bekker, M. G., Operational definitions of mechanical mobility of motor vehicles, Ordnance Corps, Land Locomotion Res. Branch, Res. & Develop. Div., OTAC Rep. 40, 100 pp., June 1958.

Use of operations research techniques are proposed to optimize mechanical performance of vehicles within given spectra of terrain conditions. Optimized value of soil-vehicle system is proposed as definition of mechanical mobility within that system. Proposed procedure leads directly to establishment of mathematical models of mobility within given system, enabling computing techniques to replace proving ground tests in mobility evaluation. This permits mobilities of all conceivable soil-vehicle systems to be evaluated, which has hitherto been physically impossible, leading to future rationalization and economy of research and development policies.

From author's summary by T. K. Chaplin, England

5539. Brooks, F. C., Effect of impenetrable obstacles on vehicle operational speed, Ordnance Corps, Land Locomotion Res. Branch, Res. & Develop. Div., OTAC Rep. 28, 11 pp., Feb. 1958.

Operational speed of a military vehicle (its velocity in desired direction) over firm flat terrain is less than *actual speed*, as it must go round obstacles. For N obstacles per square mile of length or diameter L, randomly positioned, ratio of operational speed/actual speed = $1/[1 + K N L^2]$, where K varies between 0.106 and 0.25 for cases considered.

T. K. Chaplin, England

5540. Hegedus, E., Drag coefficients in locomotion over viscous soils, Part I, Ordnance Corps, Land Locomotion Res. Branch, Res. & Develop. Div., OTAC Rep. 25, 17 pp., Jan. 1958.

To investigate vehicle drag in a fluid mud, model tests were made on wheel rolling in bentonitic mud. Analysis treats soil as viscous fluid, using measured viscosity values and principles of fluid dynamics. Tests showed wheel of round cross section gave roughly one half the drag of corresponding rectangular section wheel.

Reviewer believes results should only be applied to other soil types with great caution. Bentonite has high activity, low permeability, high true cohesion and high plasticity index, very different from most soils.

T. K. Chaplin, England

Processing of Metals and Other Materials

(See also Rev. 5688)

Book—5541. Roll, F., Handbook of foundry technology, Vol. I, Part 1 [Handbuch der Giesserei-Technik, Erster Band. 1. Teil], Berlin, Springer-Verlag, 1959, xvi + 892 pp. DM 136.

This handbook is a critical review of the current status of foundry technology and science with respect to the cast iron-carbon alloys. A number of top-ranking specialists have collaborated to make this publication both theoretically and practically comprehensive. A four-volume edition is contemplated; the first part treats the metallurigcal fundamentals of foundry practice such as the crystallization of metallic melts and the properties of liquid alloys. Cast steel, malleable iron and ornamental castings are next considered. A very detailed discussion of raw materials constitutes the third major portion. Both metallic and nonmetallic components are included. The chapter on foundry clays is especially noteworthy, and much material never before published is presented. An extensive chapter on sand and nondestructive testing concludes the first volume. A section on surface treatments is appended.

The material is well documented, profusely illustrated and readily understandable. Bibliography and index are adequate. Book is a valuable addition to the technical literature.

H. Heine, USA

5542. Johnson, W., Over estimates of load for some two-dimensional forging operations, Proc. Third U. S. Nat. Congr. Appl. Mech., June 1958; Amer. Soc. Mech. Engrs., 1958, 571-579.

The pressure to forge thick material with two dies of unequal width to cause the equal sideways displacement of material is derived using a slip-line field. The results are compared with those obtained using a discontinuous velocity field. Forging with two similar dies which cause unequal sideways material displacement is next examined. For thin material the forging pressure is determined using discontinuous velocity patterns for equal-width perfectly rough dies. Similarly, instances in which the die widths are unequal, where flashes are formed and where the dies are perfectly smooth, are examined. Finally, forgings in which material flows in four perpendicular directions are discussed.

From author's summary

5543. Ito, K., The plastic working ability test of sheet plastics by a deep drawing process, Proc. Third U. S. Nat. Congr. Appl. Mech., June 1958; Amer. Soc. Mech. Engrs., 1958, 563-569.

The plastic working ability of materials, especially the advisability of hot or cold working, is described on the basis of forming ability and retentivity. The deep drawing process is applied to various sheet plastics, at both room and elevated temperatures, as a most suitable method of testing the plastic working ability of sheet materials. The relationships between the limiting drawing coefficients and working temperature of several sheet plastics are examined. The influences of hot and cold punches in celluloid and also of fully-cured and under-cured phenol laminates on their plastic working ability are compared.

From author's summary

5544. Johnson, W., Upperbound loads for extrusion through circular dies, *Appl. Sci. Res.* (*A*) **7,** 6, 437-448, 1958.

5545. Culver, L. E., and Ford, H., An experimental study of some variables of the tube-expanding process, Instn. Mech. Engrs., Prepr., 11 pp., 1958.

This paper deals with certain aspects of the tube-expanding process. The factors investigated are (1) retubing, (2) the starting position of the roller cage within the tube, and (3) the initial clearance between tube and seat. A few tests are also reported on the relaxation of the joint with time.

In the retubing tests, further tubes were expanded into seat plates used in previous tests, from which the original tube had been removed. The main conclusion was that seat pressures can approach the theoretical maximum in retubing, and that if an extra pass is made to take advantage of the workhardened seat, a stronger joint than in a first expanding results.

To study the effect of the starting position of the rollers within the joint, four complete tests were made. The results show conclusively that a much stronger joint is obtained with less work if the rollers start with their front ends almost at the back of the joint.

Tests to study the effect of the initial clearance between tube and seat showed that clearance is not a major factor in joint strength.

From authors' summary

5546. Kuchin, A. V., Influence of the degree of cold deformation (cold hardening) on the mechanical properties of nonmagnetic steel (in Russian), *Trudi Khar'kovsk. Politekhn. In-ta* **11,** 2, 107-115, 1957; *Ref. Zh. Mekh.* no. 3, 1958, Rev. 3520.

An experimental investigation of large forgings of nonmagnetic steel showed that by using the process of cold deformation (cold hardening) its toughness can be improved, that is to say, its yield limit and resistance to rupture; the plastic properties are thereby lowered.

From author's summary

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

5547. Kennaway, A., Some recent developments in extrusion, Plastics Progress, Imperial Chemical Industries Ltd., Plastics Division, Welwyn Garden City, Herts, England, 25 pp., 1957.

Author reviews "some recent work which seems ... to add to our knowledge of the extrusion process (for plastics)." Following a brief summary of applicable flow theory, there are short discussions of the following items: granule geometry and feed-section design, mixing, removal of volatiles, high-speed extrusion, die design, adhesion, heating and cooling methods, and some methods of measuring temperature and torque. The comments are illustrated by 18 line drawings and 7 photographs; 13 references are given. Author admittedly emphasizes ideas and developments of an I.C.I. research group and, particularly, those ideas which have been carried far enough to provide reasonably satisfactory formulations for practical application.

This reviewer found the article quite helpful in providing a picture of many important factors in the general area of extrusion processes and quite stimulating in suggesting points that deserve further study, especially high-speed extrusion and adhesion measurements. H. J. Grover, USA

5548. Shaffer, B. W., Chip formation during the turning operation in the presence of a built-up nose, Proc. Third U. S. Nat. Congr. Appl. Mech., June 1958; Amer. Soc. Mech. Engrs., 1958, 655–664.

Chip formation in the turning operation, when some of the workpiece adheres to the base of the cutting tool forming a built-up nose, is analyzed as a plane strain problem of a perfectly plastic material. A slip-line field is presented which satisfies the stress and velocity boundary conditions of the problem. The results of this solution are then applied to provide expressions for the machining force and chip-thickness ratio. The solution for the turning operation is found to approach that for the orthogonal planing operation, as the radius of the workpiece is increased.

From author's summary

5549. Tambovcev, Sz. P., Investigation of metal cutting by high-speed photographing (in Hungarian), *Magyar Tud. Akad. Musz. Tud. Oszt. Köz.* **22,** 1/3, 165–186, 1958.

Fracture (Including Fatigue)

(See Revs. 5414, 5419, 5585)

Experimental Stress Analysis

(See also Revs. 5569, 5607)

5550. Frocht, M. M., and Thomson, R. A., Studies in photoplasticity, Proc. Third U. S. Nat. Congr. Appl. Mech., June 1958; Amer. Soc. Mech. Engrs., 1958, 533–540.

This paper describes an extension of the "photoelastic" method to the plastic state. Using thin models of cellulose nitrate, factors of stress distributions were determined for several basic cases.

The extension is made possible by the establishment of a suitable stress-optic law, and the employment of the shear-difference method. The results obtained are in substantial agreement with theory and experiment. The method is at present limited to plane stress problems in the elasto-plastic state without unloading.

From authors' summary by T. J. Dolan, USA

5551. Frocht, M. M., and Srinath, L. S., A non-destructive method for three-dimensional photoelasticity, Proc. Third U. S. Nat. Congr. Appl. Mech., June 1958; Amer. Soc. Mech. Engrs., 1958, 329–337.

The shear-difference method which has recently been extended to the solution of the general space problem required taking physical slices, or sub-slices, from models containing frozen stresses. It is shown in the present paper that the data required for the three-dimensional shear-difference method can be obtained by means of scattered light without slicing the model, and perhaps even without freezing, thereby providing a nondestructive method for three-dimensional photoelasticity. The necessary theory of scattered light is developed and experimental evidence provided to show the possible accuracy in the determination of the isoclinic parameters and birefringence. The possibilities of the method are further demonstrated by determining the stress distribution along critical lines in a diametrically compressed sphere and comparing the results with theory and previous experiments.

From authors' summary

5552. Kawamoto, T., Fundamental photo-elastic studies on the shrinkage stress in massive structures (in Japanese), *Trans. Japan Soc. Civ. Engrs.* no. 61, 29–37, Mar. 1959.

Author studies applicability of photoelastic method to problems of shrinkage in massive concrete structures. As an example, stresses caused by the shrinkage of block with rectangular section or rectangular wall which are placed on the foundation (or rock base) are investigated experimentally, and their results are discussed in comparison with older studies and author's approximate theoretical results.

The experiments are conducted under the same condition as one assumed in the elastic theory, and the cases where the elastic property of foundation (or rock base) is equal to that of the concrete block are treated here. It is difficult to solve rigorously the problems for the condition of shrinkage as actually occurred, but when uniform shrinkage of the block is assumed, the states of stress can be estimated with comparative ease by the application of both stress freezing method and cementing method.

From author's summary

Courtesy, Editorial Committee of the Japan Society of Civil Engineers

5553. Klapetek, F., and Cermak, Z., Use of differential membrane for evaluation of photoelastic measurements (in Czech.), *Stavebnicky Casopis* **6,** 1, 43–52, 1958.

5554. Hiltscher, R., Photoelasticity in wood research methods and proposals, *Composite Wood* **4,** 1/2, 9–16, 1957.

5555. Adler, E., Photogrammetric measuring of deformations of structural elements and structures (in Czech.), *Stavebnicky Casopis* **6,** 2, 83–96, 1958.

5556. Bell, J. F., Normal incidence in the determination of large strain through the use of diffraction gratings, Proc. Third U. S. Nat. Congr. Appl. Mech., June 1958; Amer. Soc. Mech. Engrs., 1958, 489–493.

The basic theory of the diffraction grating method for measuring strain has been given by the author in previous publications [*J. Appl. Phys.* **27,** 1109–1113, Oct. 1956; AMR **10** (1957), Rev. 668]. Present paper describes the advantages of using normal incident light on the grating and gives the derivation of the equations which relate strain to changes in the angles of the first-order images. Also, a calibration method which will allow the measurement of 1% strains with an error of less than 5% is described. To illustrate the capability of the method, a typical strain-time curve is shown for an aluminum rod struck by an identical rod. This curve shows a maximum strain of about 1.35% with a rise time of approximately 40 microseconds.

Reviewer believes that all persons interested in strain measurements, particularly dynamic, plastic strains, will find this paper, as well as the others on the same subject published by the author, very interesting. E. A. Ripperger, USA

5557. Anderson, J. R., Notes on some simple strain gauge networks commonly used with wind tunnel balances, *Aero. Res. Counc. Lond. Curr. Pap.* 415, 14 pp., 1959.

Wheatstone bridge networks of four and of eight resistance strain gages are considered from the point of view of the errors which may arise from the assumption of a linear relation between applied strain and bridge output. The effects of mismatch of initial resistance and gage factor are also examined.

From author's summary

5558. Lamport, H., and Zinsser, H. H., Strain gauge measurement of output of magnetostrictive ultrasonic transducer—pitfalls of optical measurement, *J. Acoust. Soc. Amer.* **31,** 4, 435–438, Apr. 1959.

An easily fabricated, bifilar wire strain gage wound helically about the hilt of an ultrasonic magnetostrictive transducer measures amplitude faithfully and is more convenient than optical methods. Pitfalls in the usual optical method are illustrated and discussed. From authors' summary

5559. Javor, T., Measuring of deformations by magneto-electric torsion gages (in Czech.), *Stavebnicky Casopis* **5,** 6, 375–382, 1957.

5560. Haas, A., Analytical investigation of an automatic temperature-compensated gauge (in Hungarian), *Meres es Automat.* **6,** 10, 294–297, 1958.

Gages made from resistances are sensitive not only to the quantities to be measured but also to other disturbing parameters such as temperature, pressure of the environment, etc. The article discusses the relationships for the automatic compensation of these disturbing parameters, when using noncompensated measuring methods, by which the adaptability and the means of such compensation can be determined for arbitrary gages applied in generalized linear networks. From author's summary

5561. Keler, E. K., and Veselova, Z. I., Determination of the modulus of elasticity of refractory materials by resonance method (in Russian), *Ogneupory* no. 1, 21–32, 1956; *Ref. Zh. Mekh.* no. 3, 1958, Rev. 3583.

A description is given of the method for determining the resonance frequency of a test sample during deflection oscillations, with calculations for the modulus by means of the corresponding formulas. The excitation of vibrations in the test sample, the indication of resonance and the measurements of the resonance frequency were carried out with the aid of apparatus (ICh MK-1 and ICh MK-2) fumished by the Leningrad electrotechnical institute. The accuracy of measurement of the modulus of elasticity for whole (fire) bricks was in the limits of ±3%, for test samples of prismatic shape measuring 3 × 3 × 23 cm, ±7%. Comparative data for various sorts of refractory bricks is fumished. It is noted that the divergence of the dynamic modulus from the statical amounts to from 7 to 44%. The advantage of the method consists of the speed of the measurements and the possibility of determining the modulus on whole objects (fire bricks). Yu. V. Lange

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

Properties of Engineering Materials

(See also Revs. 5394, 5419, 5427, 5430, 5543, 5546, 5547, 5591)

Book—5562. Marin, J., edited by, Materials engineering design for high temperatures (Proceedings of a short course held at Pennsylvania State University, June 30–July 4, 1958); University Park, Pa., Pennsylvania State University, 1958, 418 pp. (Paperbound).

A short course was held in the summer of 1958 with the objective of presenting current knowledge on the response of materials to elevated temperatures and how it can be used in high temperature design.

Chapter one by John E. Dorn considers the basic aspects and physical theories of creep. Author portrays how the development of the dislocation theory and careful experimental observations on creep of relatively pure metals and alloys have made progress in the understanding of creep. The pertinent aspects of dislocation theory applied to creep are elaborated, such as: (1) Generation of dislocations at a Frank-Read source; (2) Peierl's process and kink formation; (3) Intersection; (4) Cross slip; and (5) Dislocation climb. But only processes (2) and (5) are the possible ones. Because creep can occur only by means of thermal fluctuations, creep rate is assumed to follow the Eyring rate theory and the constant before exponent e is replaced by some function of stress, absolute temperature and the details of the dislocation pattern. Experimental results are mentioned such as the influence of abrupt changes in temperature upon the creep rate, variation of the activation energy with absolute temperature and the relation of these energies to those of self-diffusion. Author concludes his work with an enumeration of the unknown areas in our understanding of creep.

J. D. Lubahn in Chapter II expounds on inelastic deformation. The tension test in all of its aspects is discussed for room temperature conditions, especially the Bauschinger effect. A summary of the behavior of creep phenomenon follows, comparing constant stress with constant load tests. Several graphs explain anelastic creep. Author emphasizes the interrelation of strain rate and temperature upon the stress strain diagram, and states how strain hardening is related to strain rate and the shape of the creep curves. The mechanical equation of state concept is useful for constant temperature and no metallurgical changes. With skill it may be applied to cases of varying temperature and unstable structure. Strain aging and recovery are compared, portrayed with many graphs. Multi-axial stress conditions are depicted from results obtained in thin-walled tubing in various stress states. Laws of plasticity are summarized very well with the limitations for use at high temperatures. An outline procedure for solving problems concludes the work.

Lubahn continues in Chapter III with a lengthy survey of low-temperature brittle fracture. The nomenclature is clear. The problem is stated with a discussion on sudden failures at low stresses and sudden failure due to easy crack propagation. Author sets forth clearly the dilemma of a design engineer. There is a review of the effects of several factors on ductility and mode of crack propagation. Many curves are presented to show the behavior of mild steel as the temperature of testing varies under different geometries. Author contrasts well the factors influencing brittle fracture and those influencing strength in mild steel. Many comments appear regarding crack initiation and propagation. The discussion on alloy steels concludes that low observed nominal strengths are due to stress concentration factors, but such factors are not a sufficient condition for low nominal strength. Some time is spent in explaining notched tensile tests and impact tests, including a comparison of advantages and disadvantages. Author expounds several failure criteria for design, such as statistical theory of failure, theories of Griffith-Orowan formula, concepts of limiting stress for failure, concepts based on use of nominal strength and that of ductility "run out" locally. Numerous charts and tables enable one to review this matter in a few pages rather than searching numerous articles. Article is concluded with observation that strength could get as low as the unnotched fracture stress divided by the stress concentration factor if the ductility became zero, but strength of metals never falls as low as this limiting strength.

Conventional, resonance and acoustic fatigue of structural materials at elevated temperature are discussed in Chapter IV by B. J. Lazan. Author reviews current knowledge on fatigue life, statis-

tical aspects, progressive fracture and physical concepts. Fatigue at elevated temperature under the combined influence of alternating and mean stress is presented well. Author notes our dilemma in handling fatigue under a loading spectrum. Also, the difficult area of combined fatigue and creep is summarized. Next, the general role of material (stress-strain hysteresis) damping is covered in minimizing near-resonant fatigue stress. Author uses specific damping to describe damping properties of materials and emphasizes that rather small differences in fatigue strength are accompanied by large differences in damping energy. This chapter ends with a discussion of acoustical fatigue and urges that conventional fatigue strength be considered with the damping and stiffness properties of the material and structure.

The important problem of cyclic temperature fatigue is handled by L. F. Coffin, Jr., in Chapter V. This is a complete discussion of all current research on thermal fatigue. A method for conducting thermal fatigue studies is illustrated profusely and the several results appear in graphical form. Author shows influence of prior cold work, stress and strain cycling, change in stress range, mean temperature, speed of cycling, plastic strain range, and in-phase relations between temperature and strain cycling, all upon thermal fatigue. Author has conducted extensive constant-temperature strain cycling tests because of the complex cyclic temperature tests. Curves of many materials are presented in which log of plastic strain is plotted against log of cycles to rupture. All of these curves are parallel. Other factors related to strain cycling are included, such as strain localizing, cyclic strain-induced creep, and applications to design.

Modern steam turbines operate over an extreme range of temperature and pressure. In Chapter VI, M. J. Manjoine ably discusses the application of material properties to the design of steam turbines. A designer has a labyrinth of failure criteria to apply. At low temperatures the yield stress is the criterion. If limiting strain is not to be exceeded then creep strain must be a criterion. Members can buckle under compression due to either elastic, plastic or creep buckling. Brittle failures must be avoided and crack propagation prevented. Fatigue failures are to be prevented. Failure can occur due to relaxation. Theories of strength and plastic flow are applied to creep problems in conjunction with the equilibrium equations, and creep strains obtained using numerical integration methods.

Chapter VII is a thorough review of the creep design of pressure vessels as applied to nuclear reactors, by C. C. Bigelow and N. H. Triner. Some comments are made on nuclear reactors and the unusual problems. Authors stress the practicality of extrapolating lead model tests to operating conditions. Their mode of attack is to analyze creep under combined stresses, using Soderberg's method for thin-walled cylinders, hemispheres, ellipsoidal heads, special purpose shells and flat circular plates under transverse loading. Effective creep rate is related to effective stress by the power law. The use of isochronous stress-strain curves is used in conjunction with a graphical solution as an alternate approach to creep problems. Laws of plastic flow are assumed valid.

Gatewood in Chapter VIII explores the design of aircraft structures under steady and transient temperatures. The presentation emphasizes the great importance for reliable property data at several temperatures and the use of a wider range of properties than at room temperature. Creep buckling stresses enter all structural design. These are correlated using Larson-Miller parameters. Much use is made of the Ramberg-Osgood method of approximating stress-strain diagrams. There are many curves depicting optimum design of columns. Author timely indicates the need for designing with a variable modulus of elasticity. Problems of stringer elements are reviewed at great length, including thermal stress relaxation and residual stresses, as well as cyclic temperatures and inelastic thermal stresses in plates and box beams. This study finishes with the effects of thermal stresses on deflections and stiffness; and the deflection due to cross-section rotation.

Chapter IX concludes this course with creep design applied to gas turbines. S. S. Manson considers the strength of aircraft turbine fir-tree bucket fastenings. This is the result of several years work under NACA. There are many figures. Secondly, design methods for determining stress distributions involving creep are outlined. The method of successive approximations for solving nonlinear differential equations is applied to plastic flow and creep problems. Convergence is considered and author shows how powerful the method can be. This chapter concludes with an excellent comparison of the several parameters used for correlating and extrapolating creep and stress-rupture data. The detail permits one to evaluate the Larson-Miller, Manson-Haferd and Dorn parameters. Author notes the advantages of parameters in designing and planning experimental programs.

H. Majors, Jr., USA

Book—5563. Material properties handbook, Vol. I: Aluminium alloys, (AGARD Publication), London, Technical Editing and Reproduction, Ltd., 1958.

Handbook attempts to bring together within one cover all the important engineering properties of aluminum alloys useful for aircraft design. Its scope is supposed to be international in nature as it contains characteristic specifications of aluminum alloys from all NATO countries, viz, Canada, France, Italy, U.K. and U.S.A. Data from Germany and the Netherlands will be included as a subsequent addition to this volume. Greece, Norway and Turkey are not included as they do not produce aluminum alloys for structural aircraft use. In each national section (except in Canada where specifications are practically identical to the equivalent U.S. alloys), there is given for each alloy a set of sheets on physical and mechanical properties at room and elevated temperatures ranging up to 300 C preceded by general notes on heat treatment, cladding thicknesses of plates and testing procedures. Among the engineering properties given for different alloys are ultimate tensile stress; 0.1 and 0.2% proof stress in tension and compression, and 0.5% proof stress in compression; ultimate shear and bearing stress; yield stress in bearing; shear modulus and modulii of elasticity in tension and compression; and ultimate elongation.

The notation for most of the properties varies for different countries; consequently, the reader has to turn back to the notation page to identify each symbol used. Thus, ultimate tensile strength is denoted by "R" for France and Italy, by "f_t" for U.K. and "*Ftu*" for U.S.A. Reviewer feels that uniformity in notation could ease the work of the designer considerably by keeping the symbols of different terms the same for all the countries. The handbook has no pagination. Admittedly, serial pagination would not be possible in a work of this nature; however, for each country there could be an alphabetical prefix such as A-1, A-2 for Canada, B-1, B-2 for France, etc. These minor observations in no way detract from the utility of this publication, which through its authoritative contents and compilation will go a long way in helping engineers to effectively use aluminum alloys. The loose-leaf binding is excellent, and the overall printing leaves little room for criticism.

S. K. Ghaswala, India

5564. Fitzgeorge, D., and Pope, J. A., The thermal and elastic properties of eight cast-irons, *NE Coast Instn. Engrs. Ship. Trans.* **75,** 6, 285–330, Mar./Apr. 1959.

Paper concerns an investigation, made on behalf of the British Shipbuilding Research Association, of the mechanical and thermal properties of eight different cast-irons. At the present time all these irons are considered suitable material for combustion-chamber parts of marine diesel engines.

It was hoped that a thorough investigation of the various material properties would enable use to be made of the Eichelberg "quality factor," which is a theoretical expression designed to discriminate between "good" and "bad" materials when subjected to temperature gradients, as in an engine. However, the applica-

tion of the quality-factor expression (even though suitably modified) was strictly limited, and in cases where it was applicable the distinction obtained between materials was not sufficiently definite to allow its use as a reliable indicator. This led to the conclusion that further purely theoretical work on the problem would be unlikely to yield useful results.

From authors' summary

5565. Ridner, E. A., and Chekmarev, A. P., Influence of temperature, deformation rate and deformation on plastic resistance of carbon steels (in Russian), *Izv. Akad. Nauk SSSR, Otd. Tekh. Nauk* no. 12, 22–29, Dec. 1957.

The stress-strain curves were determined for carbon steels for the temperature range 900–1200 C at strain rates of 2-300 cm/sec to obtain data of use in mechanical working of steel. The dynamic stress-strain curves were obtained on a device, described in detail, which causes the deformation to occur when a pawl on a flywheel engages one grip of the specimen while the wheel is rotating at the desired rate of speed. The stress is recorded on an oscillograph from the deformation of a strain-gage weigh-bar in series with the specimen. The strain is estimated from the time and strain rate. A ten-fold increase in the strain rate gives a 10–75% increase in the stress. The stress varies linearly with log rate with some deviations (to higher stresses) at high strain rates. The shape of the stress-rate curves is independent of the deformation and the temperature. The effect of increasing the rate is greater for the hypoeutectoid steels. R. W. Guard, USA

5566. Liberman, L. Ya., Sensitivity of heat-resistant alloys to notching (in Russian), *Metallovedenie i Obrabotka Metallov* no. 7, 51–59, 1957; *Ref. Zh. Mekh.* no. 4, 1958, Rev. 4878.

In a review article on matter given in foreign journals the following was noted: (1) samples cut from parts of large sections are more sensitive to notching; (2) for the reliable determination of the value of prolonged durability the tests have to cover long periods of 10,000–20,000 hours; (3) the behavior of heat-resistant steels in conditions of creep and presence of notches is determined not only by means of the duration of the test and the temperature but also by means of the radius and depth of the notch; (4) heat-resistant steels exhibit sensitivity to notching when there is evidence of plasticity in the notch (characterized by constriction of the transverse section) of less than 3%, when it appears to be inadequate for the elimination of the emerging concentration of stresses in the bottom of the notch.

The article contains a large number of curves for various alloys at temperatures up to 1000° and yield strengths of up to 200 Kg/mm². A. M. Sinyukov

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

5567. Mulhearn, T. O., The deformation of metals by Vickers-type pyramidal indenters, *J. Mech. Phys. Solids* **7**, 2, 85–96. Mar. 1959.

It has been confirmed that the mechanism of identation proposed by Hill *et al.* (1947), for the indentation of a plane surface by a wedge, operates when the wedge semi-angle is less than about 30°. If the wedge angle is greater than 30° a different mechanism appears and becomes progressively more important with increasing wedge angle. This mechanism approximates to a radial compression centered close to the line of first contact of the wedge.

Indentation by conical and pyramidal indenters having an apex semi-angle of 68° also approximates to a radial compression which produces hemispherical surfaces of constant strain centered close to the first point of contact between the indenter and the specimen. With blunt indenters, variations in the indenter shape cause very little difference in the deformation mechanism except, perhaps, in a highly deformed region close to the indenter.

From author's summary

5568. Iagn, Iu. I., and Shishmarev, O. A., Some results of an investigation of elastic state limits of plastically drawn nickel samples, *Soviet Phys.-Doklady* **3**, 2, 431–433, Dec. 1958. (Translation of *Doklady Akad. Nauk SSSR (N. S.)* **119**, 1, 46–48, Mar.–Apr. 1958 by Amer. Inst. Phys., Inc., New York, N. Y.)

5569. Mansfield, E. H., On the necking of test specimens, *Engineer, Lond.* **206**, 5370, 999–1000, Dec. 1958.

This note considers the effect of necking on the stress-strain curve measured during a tensile test in a straining machine. Attention is focused on the stress and strain at the onset of failure. From author's summary

5570. Ivanov, Yu. M., Elastic deformation of timber (in Russian), *Kolloidn. Zh.* no. 3, 293–298, 1957; *Ref. Zh. Mekh.* no. 4, 1958, Rev. 4899.

Author recognizes a distinction between two regions of deformation when under the influence of a constant prolonged active stress: the region of ordinary elasticity and the region of intensive development of after-effect deformation. The border line between these regions appears to be the stress σ_0, designated by the author as the limit of plastic flow (yield). With stresses exceeding σ_0 the intensive development of after-effect deformation is accompanied by a continuous irreversible fall of the modulus of elasticity, retaining a continual lowering of value when there is a successive application of stress less than σ_0. The deformations in the second region appear to be retarded elastic deformations, that is, reversible by nature under the action of humidity and temperature.

F. P. Belyankin

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

5571. Coleman, B. D., On the strength of classical fibers and fiber bundles, *J. Mech. Phys. Solids* **7**, 1, 60–70, Nov. 1958.

Paper discusses tensile strength distributions for fibers (called "classical fibers") whose strength is independent of the rate of loading. Reasons are presented for expecting, in the absence of all other information, that the tensile strength of long classical fibers from a common stationary source should obey the Weibull distribution. The statistical theory of the strength of bundles of classical fibers, as developed by Daniels, is applied to infinite bundles composed of fibers which obey the Weibull distribution. It is found that the ratio of the tensile strength (units of force at break per initial unit area) of a bundle to the mean tensile strength of the constituent filaments decreases monotonically with increasing dispersion in the strength of the constituent filaments. In general, the tensile strength of a large bundle has the same order of magnitude, but is *less* than the mean strength of the component filaments. Previous calculations have yielded this conclusion for fibers with a special time-dependence to their tensile strength; here it is shown that the conclusion also applies to classical fibers. From author's summary

5572. Beljankin, F. P., Strength of wood in shear along the fibers (in Czech.), *Stavebnicky Casopis* **5**, 5, 269–291, 1957.

5573. Lobel, G., Contribution to the theoretical estimation of the tension in the yarn in the spinning balloon (in German), *Faserforsch. u. Textiltech.* **9**, 10, 425–431, Oct. 1958.

After deriving the elementary balloon theory, formulas are developed to make the calculation of the tension in the yarn possible for all practically occurring steady working states at any place within the balloon piece by using a curve network.

From author's summary

5574. Chambers, R. E., and McGarry, F. J., Tensile and compressive properties of fiberglass reinforced laminates, *ASTM Bull.* no. 233, 40–44, Oct. 1958.

A newly developed technique using integrally bonded foil resistance strain gages permits interior distortion measurements through the thickness of fiberglass-plastic laminates. This makes possible a detailed examination of orthotropic theory and an evaluation of the effects of certain parameter variations to better understand laminate behavior. Detailed studies of tensile, compressive, and flexural actions establish a consistent correlation between such actions and indicate that partial failure of the resin during tensile stressing takes place both in uniaxial and flexural tests. This failure, indicated by the knee in the stress-strain curve, has been further verified by moisture absorption under prolonged water immersion of laminate specimens before and after tensile stressing. Practical implications of this partial internal failure are noted.

From authors' summary

5575. Volodin, V. P., Measurement of the dynamical-mechanical properties of rubbers in the sonic range of frequencies (in Russian), Avtoref. Diss. Kand. Fiz.-matem. Nauk, Leningrad Politekhn. In-ta, Leningrad, 1957; *Ref. Zh. Mekh.* no. 4, 1958, Rev. 4290.

5576. Jambor, J., Cellular concrete, Parts I and II (in Czech.), *Stavebnicky Casopis* **5,** 5, 306–323, 1957; **5,** 6, 361–374, 1957.

5577. Carelli, R. M., On ceramic-metallic materials, ceramic materials and high-temperature protecting lines for jet engines (in Italian), *Aerotecnica* **38,** 2, 71–87, Apr. 1958

Structures: Simple

(See also Revs. 5355, 5368, 5369, 5445, 5466, 5478, 5495, 5501, 5503, 5504, 5529, 5576, 5828)

5578. Sankaranarayanan, R., and Hodge, P. G., Jr., On the use of linearized yield conditions for combined stresses in beams, *J. Mech. Phys. Solids* **7,** 1, 22–36, Nov. 1958.

In order to find an upper and lower bound to the collapse load of a structure subject to combined bending and torsion, two problems have to be solved, each of which is based on a nonlinear interaction curve. The problem of finding bounds is considerably simplified when the interaction curves are replaced by two similar octagonal yield curves, one which inscribes and the other which circumscribes the nonlinear interaction curves. The lower bound of the collapse load may be found by using the inscribed octagon in the analysis, while an upper bound may be obtained by multiplying the lower bound value by a suitable factor.

The procedure is illustrated by studying the collapse load of an angle bent loaded perpendicular to its plane and by studying the collapse load of a three by three grid carrying a concentrated load P on each of its nine joints. B. W. Shaffer, USA

5579. Higgins, T. R., Plastic design in steel—A progress report, *J. Boston Soc. Civ. Engrs.* **45,** 3, 207–226, July 1958.

5580. Hemp, W. S., Theory of structural design, *Coll. Aero. Cranfield Rep.* 115, 63 pp., Aug. 1958.

Paper is concerned with general design problem of finding optimum structure "which will equilibrate external loads without failure or undue deformation." Theorems of Maxwell and Michell pertaining to this subject for space frames are derived and implications and restrictions on frame layout are explored. Applications of theorems to simple design problems, due to H. L. Cox, are described. Further developments are given for continuous plates and plate-like structures consisting of an orthogonal array of closely spaced fibers. Author concludes with suggestions for future lines of research. P. Seide, USA

5581. Goldberg, J. E., General instability of low buildings, Proc. Third U. S. Nat. Congr. Appl. Mech., June 1958; Amer. Soc. Mech. Engrs., 1958, 339–342.

A theory of general instability of one-story building structures is presented. The individual parallel, plane frames of the structure are assumed to be coupled by a bracing system which, in turn, is supported by elastic walls or frames. A lurching mode of general collapse is investigated. The prediction of stability or instability under a given set of loads is reduced to a small sequence of computationally simple problems.

From author's summary

5582. Shield, R. T., and Drucker, D. C., Limit strength of thin-walled pressure vessels with an ASME standard torispherical head, Proc. Third U. S. Nat. Congr. Appl. Mech., June 1958; Amer. Soc. Mech. Engrs., 1958, 665–672.

Results are presented for the maximum pressure which an unfired vessel with an ASME standard torispherical head can withstand before appreciable plastic deformation will occur. The effect of flanges on strength is considered. Although the procedures outlined permit variation of pressure in the axial direction to be taken into account fully, for convenience the calculations are based upon the assumption of uniform interior pressure. Work-hardening is not of much significance for thin-walled vessels of the usual steels and is ignored. A comparison is made with the ASME Code for unfired pressure vessels. A real danger is pointed out which is especially important in connection with brittle fracture at low temperature.

From authors' summary

5583. Abeles, P. W., Losses of prestressing force. Part I, *Concrete Constr. Engng.* **53,** 8, 285–296, Aug. 1958.

5584. Abeles, P. W., Losses of prestressing force, Part II, *Concrete Constr. Engng.* **53,** 9, 331–340, Sept. 1958.

5585. Jain, O. P., A new plastic theory for reinforced concrete, *J. Instn. Engrs., India* **39,** 2 (Part I), 71–97, Oct. 1958.

The new theory consists in a concrete stress-strain diagram simplified to a linear elastic and a constant plastic part, as, f.i., mild steel. Introduction of the elastic part makes a calculation of deformations theoretically possible.

Reviewer finds it doubtful that this method gives an improvement of correlation with test results which justifies the complication of formulas, etc. A. Selberg, Norway

5586. Xenakis, Y., The Philips pavilion at the 1958 Brussels World Fair, Part I; The architectural design of Le Corbusier and Xenakis, *Philips Tech. Rev.* **20,** 1, 2–8, 1958/59.

A brief explanation is given of the visual, acoustical and architectural considerations that led to the design of the pavilion as a structure composed entirely of ruled surfaces, namely hyperbolic paraboloids. The evolution of the first design, which included conoids, is illustrated by a series of sketches, and a description is given of the method, half experimental and half geometrical, by which the surfaces of the first design were converted completely into hyperbolic paraboloids (second design). With this conversion it was possible to adopt the scheme of construction proposed by the contracting firm, "Strabed," which was to build the pavilion as a self-supporting shell in prestressed concrete 5 cm thick. From author's summary

5587. Vreedenburgh, C. G. J., The Philips pavilion at the 1958 Brussels World Fair, Part II; The hyperbolic-paraboloidal shell and its mechanical properties, *Philips Tech. Rev.* **20,** 1, 9–17, 1958/59.

After a recapitulation of the principal geometrical properties of the hyperbolic paraboloid (hypar), author gives a synopsis of the

membrane theory of the hypar shell. The differential equations for the state of stress can be very simply solved in the case of a uniaxial uniform load parallel to the axis of the shell. The shell can then be considered as a structure of equal strength. The author also provides formulas for some more complex loads which may occur in practice, and describes a simple graphical method for determining the principal shell forces and the prestressing forces needed if tensile stresses are to be avoided in the material (concrete). Finally, attention is devoted to the edge disturbances which appear when the boundary conditions are such as to locally preclude a purely membrane state of stress, and to the stability of the hypar shell against buckling and second-order buckling ("oil-canning"). From author's summary

5588. Bouma, A. L., and Ligtenberg, F. K., The Philips pavilion at the 1958 Brussels World Fair, Part III; Model tests for proving the construction of the pavilion, *Philips Tech. Rev.* **20,** 1, 17–27, 1958/59.

A 1:25 scale model was made of the Philips pavilion, after the design of the architect. The model was built of plaster of Paris on a framework of wire-gauze, with steel tubes as the ribs. The states of stress produced in the model under different loads (dead-weight, wind, etc.) were investigated with a large number of strain gages and displacement gages. The conclusion was that a structure of 5-cm thick concrete with 40-cm thick ribs would be sufficiently strong. In a second model, scale 1:10, two of the shell surfaces (formed as hyperbolic paraboloids) were built up from several hundreds of appropriately shaped plywood slabs. These shell surfaces were prestressed, and the results observed demonstrated the feasibility of the proposed system of construction, using precast concrete slabs and prestressing wires anchored in the ribs. From authors' summary

5589. Duyster, H. C., The Philips pavilion at the 1958 Brussels World Fair, Part IV; Construction of the pavilion in prestressed concrete, *Philips Tech. Rev.* **20,** 1, 27–36, 1958/59.

The oddly-shaped shells of the pavilion could not be made by casting concrete in shuttering. The contractors "Strabed" therefore built up the 5-cm thick walls from slabs about 1 square meter in size which were precast on sand moulds and, after assembly on scaffolding, were pulled tightly together by steel wires. This construction is also mechanically advantageous since, with suitable prestressing of shells and edge members, a membrane state of stress can be approached. The precasting and assembly of the slabs was greatly simplified by the fact that the walls are ruled surfaces (hyperbolic paraboloids). The prestressing wires, applied to both surfaces of the shells, follow mainly the ruling lines. They were tensioned by a special system devised by "Strabed." In addition to compressive and bending prestresses, some ribs were given torsional prestresses (probably the first instance of torsional prestressing in concrete).

From author's summary

5590. Habel, A., Practical computation of creep deflection of reinforced-concrete beams (in German), *Bautechnik* **34,** 2, 64–66, Feb. 1958.

Paper gives a rather conventional computational method for creep deflections of reinforced-concrete beams. The main value of the paper is in the graphs and tables provided for the selection of creep constants for various types of concretes and various reinforcement ratios. This, however, is based upon the German specifications. D. Vasarhelyi, USA

5591. Pavlik, A., A remark about the strength of concretes (in Czech.), *Stavebnicky Casopis* **6,** 2, 97–115, 1958.

5592. Engalychev, S. A., Application of the projection method for the drawing up of curves of deflection and torsional moments in three-dimensional frames (in Russian), *Trudi Leningrad Voen.-Mekhan. In-ta* no. 6, 141–144, 1957; *Ref. Zh. Mekh.* no. 4, 1958, Rev. 4655.

5593. Tamarin, A. A., Deformations of stressed reinforced elements (in Russian), *Transp. Str-vo* no. 12, 15–20, 1956; *Ref. Zh. Mekh.* no. 4, 1958, Rev. 4757.

The deficiencies and defects of existing instructions (standard) (I-148-52) are criticized. The analysis made in support of the criticism showed the necessity for lowering the disruption moment in the case of an insufficient magnitude being assigned for the prestressed reinforcement, and also indicated the possibility of simplifying the calculations for crack stability by comparing the deflections of components due to the operating load with the deflections permissible by the conditions safeguarding the crack stability. M. A. Zadoyan

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

5594. Camiz, V., Fundamentals of a general method for the solution of two dimensional frames, Parts I, II, III, The connections of frames; The resolvent equation; The variation of temperature and the yielding of supports (in Italian), *G. Gen. Civ.* **96,** 10, 636–644; Oct. 1958; **97,** 1, 52–61, Jan. 1959; **97,** 1, 62–66, Jan. 1959.

This series of three papers develops the general equations of a planar framework taking into account the elongations and contractions of members. The generalized coordinates used are the positions of the joints; for example, the radial and angular displacements of the center of joint A with respect to the center of joint B, and the rotations of joints A and B. The equations are in general form and are not applied to a particular frame.

G. Housner, USA

5595. Sager, J., Contribution to the calculation of structural frames with horizontal loads (in German), *Beton u. Stahlbeton.* **53,** 12, 309–311, Dec. 1958.

Using moment area and distribution methods, author analyzes single-bay multistory frame under lateral loads applied at floor levels. G. G. Meyerhof, Canada

5596. Morgan, V. A., Gable frames with multiple bays, *Concrete Constr. Engng.* **53,** 10, 365–374, Oct. 1958.

5597. Rabinovich, I. M., A problem in the theory of frameworks (in Russian), Investigations in the theory of construction, no. 7; Moscow, Gostroiizdat, 1957, 607–615; *Ref. Zh. Mekh.* no. 4, 1958, Rev. 4679.

It is noted that, in calculations for frameworks possessing m rods, of which n are essential and $(m - n)$ are surplus, the necessity always arises to arbitrarily assign m parameters. Thus for a statically determinable framework stress values are assigned for all of the $m = n$ rods; in calculation of a redundant framework by the method of forces, sectional areas are assigned for the whole of the m rods; in applying the method of given stresses, stresses (or elongations) are assigned to n necessary rods, and sections (or forces) to $(m - n)$ surplus rods. In all these cases, the displacement of the joints is stated as the result of the calculation, and the rational regulation of the rigidity of the framework is difficult. Such regulation, essential for the calculation in the second boundary condition, and also for the dynamic calculation, permits the use of the proposed "method of given stresses and displacements," in which the number of assigned parameters is included: (a) $p \leqslant n$ components of displacements of some joints; (b) $(n - p)$ stresses (or elongations) in some essential rods, not dependent on their values; (c) $(m - n)$ section areas (or forces) in the surplus rods. The geometrical and energo-statical relationships are indicated, guaranteeing the progressive calculation of

the framework by one scheme of loading without solving the system of equations. While having the appearance of being a generalization of the method of assigned stresses, the proposed method retains its superiority over the method of forces, but becomes more flexible. In calculating for more than one scheme of loading the solution becomes more complex and leads to the use of the system of equations. Ya. B. L'vin

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

5598. Koprna, M., The traverse method (for analyzing continuous structures). Parts I, II and III (in Czech.), *Stavebnicky Casopis* **5,** 3, 198–203, 1957; **5,** 4, 218–230, 1957; **5,** 5, 292–305, 1957.

5599. Little, A., The influence of site investigation on construction methods, Proc. Midland Soil Mech. Found. Engng. Soc. **1,** Pap. no. 3, 21 pp., Mar. 1957.

5600. Oswald, E., Moment distribution method in the case of unfavorable convergence conditions (in German), *Bautechnik* **34,** 2, 59–64, Feb. 1957.

The convergence of the moment distribution method for the calculation of multistory building frames is improved by introducing a third (supplementary) group of equilibrium conditions, namely that the sum of the lower column end moments and the sum of the beam end moments must be equal to the external moment for the floor under consideration. Application is shown by a numerical example. F. Stussi, Switzerland

5601. Merchant, W., A connection between Rayleigh's method and stiffness methods of determining critical loads (in English), 9th Congrès Intern. Mécan. Appl., Univ. Bruxelles, 1957; **7,** 8–12.

By the stiffness method, the critical load of a rigid frame structure is found by computing the deflections δ due to load parameters P and a disturbing force Q, and the corresponding stiffness $K = Q/\delta$. The critical load is that load P for which K first vanishes. Author extends Rayleigh's method of finding critical load of columns to the case of rigid frames. A proof is given to show that this is equivalent to replacing the $K - P$ curve of the stiffness method by the tangent to $K - P$ curve at the origin. Although this would avoid the necessity of computing several trial loads, the author reports that Rayleigh's method may lead to unacceptable overestimation of the true critical loads.

M. L. Pei, USA

5602. Egerev, K. E., Relaxation of tangential stresses along the lateral surface of a loaded pile frozen in the ground, *Soviet Phys.-Doklady* **3,** 2, 273–275, Dec. 1958. (Translation of *Dokladi Akad. Nauk SSSR (N. S.)* **119,** 2, 223–225, Mar.–Apr. 1958 by Amer. Inst. Phys., Inc., New York, N. Y.).

A redistribution of tangential stresses, for a known relationship between the load and the length of the pile, takes place, accompanied by a decrease in stresses following their relaxation in the upper section of the pile and a certain stress increase without relaxation in the lower part.

The long-term strength of the congelation of sandy loam with duraluminum has reached values $\tau_{l.t.} = 2.40$ kg/cm² for ground temperatures of -2.1 to -3.1 C.

The long-term strength of the congelation of the same ground for the same temperatures and moisture content with a reinforced-concrete pile must have large values since the reinforced-concrete surface has a greater roughness than the surface of the duraluminum measuring tube. From author's summary

5603. Beck, H., Contribution to the theory of sheet string panels (in German), *Ing.-Arch.* **26,** 5, 343–357, Oct. 1958.

As an accurate translation of the original title seems nearly impossible, the German title is restated here: "Ein Beitrag zur Berechnung regelmässig gegliederter Scheiben."

The panels under consideration are multistory rectangular frames made from very stiff beams and regularly spaced slender columns. This type of panel is now often used as front wall of buildings. Paper develops a procedure for the approximate calculation of such systems. The frame is replaced by an equivalent continuous structure. Author succeeds in reducing all the parameters of this replacement frame to only one unknown function, which is defined by usual linear differential equation of the second order. The statically indeterminate quantities of the given frame are obtained by integrating the corresponding functions of the replacement continuum.

The main advantage of the method is to replace the writing and solution of a very large system of linear algebraic equations by the solution of a differential equation of known type. Author announces the publication in another periodical of simple formulas for the design of frames of the most common dimensions.

C. Massonnet, Belgium

5604. Baldauf, H., Contribution to the theory of plane trusses (in German), *Ing.-Arch.* **26,** 5, 338–342, Oct. 1958.

Author describes a method for the simultaneous determination of the axial forces, shearing forces and bending moments, acting in the bars of a plane truss with rigid joints. This method is therefore more exact than the conventional two-step procedure (i.e. the "analysis of secondary stresses in trusses"). Loads acting between the joints (e.g. the own weight of the bars) can be considered. The proposed procedure is an adaptation of a method called in Germany the "reduction method" and in Russia the "method of initial parameters." This method was first applied to different branches of physics and later introduced to the analysis of continuous beams subjected to complicated support conditions [see Falk's paper, *Ing. Arch.* **24,** 3, 216–232, May 1956; AMR **9** (1956), Rev. 3917]. The application of the method requires a fairly large amount of computations but the number of equations to be solved does not exceed six; this number may be increased by the number of redundant supports. The method cannot be applied to trusses of certain web systems (e.g. the K and the rhomboidal systems). A. Werfel, Israel

5605. Nevel, D. E., The theory of a narrow infinite wedge on an elastic foundation, *Trans. Engng. Inst., Canada* **2,** 3, 132–140, Sept. 1958.

A method is presented for the solution of a narrow free infinite wedge on an elastic foundation loaded with a uniformly distributed load for a distance r from the corner of the wedge. This problem is important in the analysis of cracked ice sheets. The differential equation which describes this is $\frac{d^4y}{dk^4} + \frac{2d^2y}{kdk^2} + y = 0$ of which the solution is: $y = A\,\mathrm{nev}_0(k) + B\,\mathrm{nev}_1(k) + C\,\mathrm{nev}_2(k) + D\,\mathrm{nel}_1(k)$ where A, B, C, D are constants of integration and $\mathrm{nev}_0(k)$, $\mathrm{nev}_1(k)$, $\mathrm{nev}_2(k)$, $\mathrm{nel}_1(k)$ are functions defined by an infinite series. From author's summary

5606. Halasz, O., Approximate calculation of coaching breadth of thick ribbed slab (in Hungarian), *Mélyépítestudományi Szemle* **8,** 6, 252–258, June 1958.

5607. Moravia, G., Study on a model in the elastoplastic field (in Italian), *Metallurgia Ital.* **50,** 12, 541–548, Dec. 1958.

Description is given of a test on a steel model of a built-in portal frame, carried up to collapse load. Deformations have been observed with electrical strain gages, and Araldite plates stuck on the steel model are studied photoelastically by reflection. Real collapse load agrees with the one obtained using plastic hinge

formation theory. Maximum deformations are approximately six times elastic ones and hence easily absorbed by model material.

A. J. Bignoli, Argentina

Structures: Composite

(See Revs. 5399, 5618, 5658, 5825)

Machine Elements and Machine Design

5608. Rothbart, H. A., Cam torque curves, *Mach. Design* **31,** 15, 127–129, July 1959.

5609. Levai, I., Data on the material-saving design of gears (in Hungarian), *Magyar Tud. Akad. Musz. Tud. Oszt. Köz.* **22,** 1/3, 99–106, 1958.

5610. Wempner, G. A., The conical disk spring, Proc. Third U. S. Nat. Congr. Appl. Mech., June 1958; Amer. Soc. Mech. Engrs., 1958, 473–478.

Paper presents an improved analysis for nearly flat conical disk springs, differing from previously available theory in that radial strains are now included. Strain energy is expressed in terms of radial displacements and rotations of tangents to the meridian, retaining certain quadratic terms. Differential equations and boundary conditions then are obtained by use of calculus of variations. Introduction of simplifying assumption that rotation of tangent has constant value into differential equation relates radial displacements to this undetermined constant and permits evaluation of energy integral in terms of one parameter, the constant rotation. Value of parameter is deduced from requirement that total energy be stationary.

Method permits considerably greater generalization of boundary conditions than has been available previously and provides information on radial membrane stress unobtainable from previous solution. Numerical example indicates a small difference in circumferential membrane stress and a significant increase in circumferential bending stress as compared with solution of Almen and Laszlo, presumably on the side of increased accuracy since a more comprehensive theory has been used.

J. E. Goldberg, USA

5611. Ripianu, A., Contributions to the study of the determination of the acceleration pole position and its employment for the determination of the forces which impinge upon the parts of plane mechanisms, to serve for the design of such mechanisms (in Roumanian), *Industria Usoara* **5,** 7, 259–269, July 1958.

The analytical and graphical method of determination is presented for the inertial forces which appear during the functioning of plane mechanisms. The frequently-met case of the cardiacal movement is analyzed.

From author's summary

5612. Carter, W. J., Second acceleration in four-bar mechanisms as related to rotopole motion, *J. Appl. Mech.* **25,** 2, 293–294 (Brief Notes), June 1958.

5613. Shchepetilnikov, V. A., The determination of the mass centers of mechanisms in regard to the problem of their balancing (in Russian), *Trudí Mosk. In-ta Inzb. Zb.-d. Transp.* no. 92/11, 211–233, 1957; *Ref. Zb. Mekb.* no. 2, 1958, Rev. 1601.

A new method is described for investigating the displacements of the general mass center of a multilink mechanism by double conformal transformation and linking by double groups to the mass center. Such an auxiliary mechanism will exactly reproduce the motion of the mass center of the original mechanism. The method is illustrated on examples of 4- and 8-link mechanisms of the second class, and mechanisms with groups of the third and fourth classes. It is demonstrated that by suitably selecting the masses and centers of gravity of the links it is possible to synthesize mechanisms balanced by means of counterweights.

M. K. Kristi

Courtesy Referativnyi Zhurnal, USSR

Translation, courtesy Ministry of Supply, England

5614. Panteleyev, S. I., A review and investigation of the structure of spatial mechanisms with contacting levers (in Russian), *Trudí Mosk. Aviats. In-ta* no. 72, 100–146, 1957; *Ref. Zh. Mekh.* no. 2, 1958, Rev. 1594.

In his considerations, author introduces vague and inaccurate definitions: structural design, structural elements, structural parameters, etc. The practical value of the work is not clear.

F. M. Kurovskii

Courtesy Referativnyi Zhurnal, USSR

Translation, courtesy Ministry of Supply, England

5615. Terplan, Z., Kinematics and dynamics of two-dimensional mechanisms (in Hungarian), *Magyar Tud. Akad. Musz. Tud. Oszt. Köz.* **21,** 1/4, 133–140, 1957.

Rheology

(See Rev. 5406)

Hydraulics

(See also Revs. 5370, 5639, 5667, 5681, 5682, 5686, 5695, 5811)

5616. Asaturyan, A. Sh., and Chernikin, V. I., Laminar motion of a viscous liquid with a free surface in cylindrical tubes (in Russian), *Izv. Akad. Nauk SSSR, Otd. Tekh. Nauk* no. 9, 137–139, Sept. 1957.

This "brief note" presents an "exact" solution of the laminar, incompressible, steady-velocity distribution and flow rate in an inclined, partly filled, straight cylindrical tube. Skillful use is made of bipolar coordinates, following previous work by Chaplygin. The Navier-Stokes equations (without inertia terms) are transformed into a Laplace equation for the unknown term of the assumed velocity function. Both the solution and the boundary conditions are expressed in Fourier integral form. Answers reduce to well-known Hagen-Poiseuille equations for filled pipe. Flow rate is obtained in terms of an integral, numerical values of which are given in table form as functions of flow geometry. Curve of flow-rate ratio against depth ratio compares solution with previous approximate formula by Essman and Lobkov. Three other references, all Russian, are listed. A small number of typographical errors are present.

T. Ranov, USA

5617. Eckart, C., Surface wake of a submerged sphere, *Physics of Fluids* **1,** 6, 457–461, Nov./Dec. 1958.

The problem of a sphere moving in a semi-infinite homogeneous liquid with a free surface is treated by the author. It is shown that the surface wake of a submerged sphere is approximately the same as that which would be caused by a traveling pressure disturbance in the atmosphere above the free surface.

If the motion is sufficiently slow, the surface reacts to this equivalent pressure as a barometer. For more rapid motions, dynamic effects reduce the response of the surface, but leave a wake in the region already traversed by the sphere. The calculation of this wake involves the usual distinction between incoming and outgoing waves, which is introduced in the Fourier transformation of the solution. The resulting integrals are evaluated by Kelvin's approximate method of stationary phase.

From author's summary by W. DeLapp, USA

5618. Sugimoto, S., On the water surface profile around bridge pier (in Japanese), *Trans. Japan Soc. Civ. Engrs.* no. 62, 33–41, May 1959.

In the present paper, author introduces a fundamental equation for water flow with vertical velocity distribution, taking the flow bed into consideration. This equation is isomorphic with the fundamental equation of the subsonic flow of air. Author performed calculation on the water surface profile around bridge pier by applying Imai's theory in the subsonic or supersonic flow, which was developed by W. K. B. method used in the solution of Schrödinger's wave equation in quantum mechanics. Furthermore, author performed experiments by using a steel framed flume and the theoretical results showed good coincidence with the experimental ones.

From author's summary

Courtesy, Editorial Committee of the Japan Society of Civil Engineers

5619. Matsunashi, J., On the instability of the movable bed in open channel flow—the theoretical analysis by using the small oscillation method (in Japanese), *Trans. Japan Soc. Civ. Engrs.* no. 61, 47–53, Mar. 1959.

Author analyzed theoretically the instability criterion of the movable bed in open channel flow by using the method of small oscillation. As a result of this research, he reached the following conclusions: first, the instability criterion of the movable bed is governed by the resistance law of the flowing water, which is based on the condition that both the water flow and the movement of bed sand are uniform. Secondly, the domain and limits of stability are generally expressible by the nondimensional quantity $Umo/U_R{}^*$ and Froude number F_*.

From author's summary

Courtesy, Editorial Committee of the Japan Society of Civil Engineers

5620. Matsunashi, J., On the instability of the movable beds in open channel flow—investigation on the experimental data of movable bed (in Japanese), *Trans. Japan Soc. Civ. Engrs.* no. 62, 25–32, May 1959.

In his last report [see preceding review] author theoretically analyzed the instability criterion of the movable bed in open channel flow. In the present paper, the theoretical results obtained are compared with the experimental data obtained by G. K. Gilbert, Dr. Tsubaki, Dr. Aki and the writer.

From author's summary

Courtesy, Editorial Committee of the Japan Society of Civil Engineers

5621. Pozdnyakov, I. T., The similarity characteristics of horizontal and inclined slow currents (in Russian), *Nauchn. Trudi Leningradsk. Inzh.-stroit. In-ta* no. 25, 59–62, 1957; *Ref. Zh. Mekh.* no. 2, 1958, Rev. 1886.

Water supply drainage and sewage systems include structures in which the water flows by gravity with very low velocities (0.5 – 5 mm/sec). The water entering such structures is not at a uniform temperature and, consequently, density. In such case, the principal effective force, exerting the greatest influence on the formation of the velocity field, is the Archimedean force. For modelling such flows, author introduces the following similarity condition

$$Ar = \frac{\gamma_0 - \gamma_1}{\gamma_0 F}$$

wherein γ_0 and γ_1 are the specific gravities of the liquid on entering and leaving the flow, F = Froude number. It is pointed out that the application of this constant enables a closer resemblance of the model conditions to the full-scale conditions to be obtained than with the systems of modelling analogy usually adopted.

E. M. Minskii

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

5622. Bernier, M., Comparison between Gumbel's and Frechet's laws on the estimation of maximum flood discharges—the asymptotic behavior of classified discharge curves (in French), *Houille Blanche* **14,** 1, 47–54, Jan.-Feb. 1959.

The statistical theory of extreme values has shown that the Gumbel and Fréchet probability laws can be made to fit flood discharge frequency distributions. It is usually very difficult to base a coherent decision as to which of these two laws to use on presently available maximum annual discharge data which does not cover sufficiently long periods.

Certain asymptotic properties of classified discharge curves, which can be used to make an a priori choice between the Gumbel and Fréchet laws, are studied here. This study includes:

(a) Examples of fitting compound Galton laws to classified discharge curves for eight streams having varying regimens.

(b) A comparison of these laws with the Gumbel distribution for high discharge values.

In conclusion, how well the Gumbel law can be made to fit flood discharges seems to be dependent upon certain hydrological characteristics of the river basins being investigated. However, this connection will have to be determined by applying the procedure to a greater number of examples and perfecting the statistical method which is used.

From author's summary

5623. Rabukhin, L. G., Calculation of the apertures of hydraulic discharges in the presence of accumulation (in Russian), *Soobshch. Akad. Nauk GruzSSR* **17,** 7, 629–636, 1956; *Ref. Zh. Mekh.* no. 2, 1958, Rev. 1900.

A method is suggested for calculating hydraulic discharge pipes with allowance for accumulation in the flow, which is based on numerical integration of the equation of hydraulic balance of the reservoir with trapezoidal admission curve, which is more accurate than the usual method of analytical solution of this equation for a rectangular admission curve [M. V. Potapov: "Works," Moscow, Selkhozgiz, **3,** p. 177, 1951].

V. V. Fandeev

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

5624. Juniewicz, S., Aulich, J., and Szling, Z., Determination of formulas for the flow over triangular weir in laboratory conditions (in Polish), Zeszyty Naukowe Politechniki Wroclawskieg, Budownictwo **6,** 29–46, 1959.

Four dimensionless relationships are established for a triangular weir. Limits of accuracy are determined for every step in calibration. The usual formula varies by ± 2%; binomial and trinomial formulas assure accuracy to ± 0.5%. Authors conclude that every weir in a laboratory should be calibrated individually.

S. Kolupaila, USA

5625. Yakovlev, I. S., The hydraulic analysis of irrigation channels by the transporting capacity of the current (in Russian), *Izv. Akad. Nauk TurkmSSR* no. 1, 38–45, 1957; *Ref. Zh. Mekh.* no. 2, 1958, Rev. 1888.

Developing a suggestion by A. A. Ugintchuss ["Canals and structures theorem," Moscow, Gos. izd-vo lit. po str-vu i arkhitekture, 1953] on the calculation of channels by a given degree of turbidity, author demonstrates the possibility of calculating channels by linking the conditions of precipitation in the channel and the irrigation source respectively. Specimen calculations and supplementary nomograms are presented.

V. N. Goncharov

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

5626. Kammerstein, A. G., The hydraulic resistance in welded, abruptly bent and folded pipe elbows (in Russian), *Stro-vo Predpriyatiy Neft. Prom-sti* no. 6, 9–11, 1957; *Ref. Zh. Mekh.* no. 2, 1958, Rev. 1876.

A discussion of the results obtained by the "Stroyneft" All-Soviet Scientific Research Establishment and the Chair of Hydraulics of the Moscow Institute of Municipal Engineers of investigations on the hydraulic resistance of pipe elbows. No experimental data are given. Some practical recommendations are made.

From author's summary

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

5627. Travaglini, G., On the extinguishment of a liquid jet emerging vertically upward (in Italian), *G. Gen. Civ.* **96,** 9, 558–569, Sept. 1958.

A vertical jet, passing through a liquid mass initially at rest, is stopped, losing practically all its kinetic energy provided the height of the liquid above the efflux orifice is greater than a certain value h, which is a function of the initial pressure head, the initial jet diameter, and the diameter of the receptacle into which the jet is injected from below. For liquid height less than h, the jet will pass through the liquid mass, rupture it and finally empty the receptacle entirely. This phenomenon is explained, an equation is derived for the extinguishment of the jet, and the results of an extensive series of tests are given. The experiments were performed under greatly varying conditions, the pressure head being varied from 5 to 100 m, the orifice diameter from 4 to 12 mm, the receptacle diameter from 50 to 120 mm, and the height of water in the receptacle from about 16 to 45 cm. Pictures are shown of the efflux from the receptacle with extinguished jet, and with the unextinguished jet rupturing and evacuating the water contained in the receptacle; for each picture the corresponding orifice diam, receptacle diam, pressure head and height of water in the receptacle are given.

K. J. DeJuhasz, Germany

5628. Poltavtsev, V. I., Problems in the theory and analysis of wide-sill spillways and measuring flumes (in Russian), *Trudi Leningrad Gidrometeorolog. In-ta* no. 5/6, 34–58, 1956; *Ref. Zh. Mekh.* no. 2, 1958, Rev. 1892.

On the basis of theoretical analysis and experimental data, author proposes an approximate method for calculating the influence of the value of flow curvature in the design of spillways with wide sills and measuring flumes. The method is based on the application of the Bernoulli equation, generalized for the case of curvature in the stream. The advantages are underlined of author's method of calculating, separately, the influences of curvature and hydrostatic pressure:

$$\frac{p}{\gamma} = h \pm k_\sigma \frac{V^2}{2g}$$

which enable quantitative evaluation of the influence of curvature, expressed by the coefficient k_σ, and correlation of the latter with other characteristics of the flow, as well as elucidation of the physical significance and structure of the velocity and flow coefficients. As a result, author obtains the expressions

$$v = \sqrt{\frac{1}{\alpha + \Sigma\zeta}} \sqrt{2g\left(H_0 - b_k + k_\sigma \frac{v^2}{2g}\right)}$$

$$Q = \varphi_\sigma b b_k \sqrt{2g\left(H_0 - b_k \quad k_\sigma \frac{v^2}{2g}\right)}$$

Commenting on the difficulty of applying these formulas in view of the necessity for determining the values of φ and K_σ, author regards it as possible, for practical purposes, to combine these in a single, referred velocity coefficient φ_σ; in which case

$$v = \sqrt{\frac{1}{\alpha + \Sigma\zeta \pm k_\sigma}} \sqrt{2g(H_0 - b_k)}$$

$$Q = \varphi_\sigma b b_k \quad \sqrt{2g(H_0 - b_k)} = m \; b\sqrt{2gH_0^{3/2}}$$

In conclusion, author examines three methods of calculating spillways with wide sills and measuring flumes: (1) For determining Q, using directly the values of $b_k = f(H)$ obtained from the analytical characteristics thereof, founded on experimental data; (2) determining the values of φ_σ and m_σ by the values of the coefficient of curvature k_σ; (3) determining the values of φ_σ and m_σ from experimental data.

A. R. Berezinskii

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

5629. Mannam, J., Further aspects of hydraulic lock, Instn. Mech. Engrs., Prepr., 15 pp., 1958.

Author considers hydraulic lock as a hydrodynamic phenomenon and investigates the side thrust resulting from several piston configurations operating in a cylinder of uniform bore. Theoretical approach utilizes Reynolds equation as applied to piston geometries, including (1) dumbbell shaped, tapered land pistons which are free to position themselves in the cylinder independently of each other, (2) stepped pistons with one and two steps. Fluid is considered incompressible. Pressure equations are given and side thrust curves shown for tapered and stepped pistons. Theoretical results show optimum position for a single circumferential groove in the piston land. Piston ovality is treated and exhibits increased side thrust over circular pistons. Computed leakage rates are presented for stepped and tapered pistons located co-axial with the cylinder. Experimental results include pressure distributions and side thrust forces for several pistons. Comparison is made between theory and experiment. Tests using air as a working fluid were made.

D. F. Hays, USA

5630. Mashkovich, L. A., The damping of energy and the regulation of the form of flow during the junction of the 'upper and lower waters' by means of hydraulic shock (in Russian), Avtorefer. Diss. Kand. Tekhn. Nauk, Tashkentsk. In-ta Inzh. Irrigatsii i Mekhaniz. S. Kh., Tashkent, 1957; *Ref. Zh. Mekh.* no. 4, 1958.

5631. Numachi, F., Cavitation bubbles and ultrasonic waves occurring on hydrofoil (in German), *Forsch. Geb. Ing.-Wes.* **24,** 4, 125–132, 1958.

Treatise continues two previous papers [*Forsch. Ing.-Wes.* **22,** (1956) and **24,** (1958) without knowledge of which the present one cannot be understood. In previous papers, the experimental arrangement is described, which consists of a supersonic responsive device (quartz crystal) connected to the sight-glass of the cavitation chamber, in the region of maximum sound intensity. Also definitions of the pressure and mean value of pressure of supersonic waves are given there, and it is stated that the maximum intensity is located at the end of cavitation region.

Present paper gives results of experiments more pronounced in this direction, using high-speed camera (6300 frames/sec). It

follows that the maximum of wave pressure, and especially of the mean value, is considerably displaced behind the region where the cavitation bubbles disappear (only bubbles greater than 0.5 mm in diameter are visible on the photograph). The frequencies of 250 and 350 kHz, by which the wave pressure has its maximum, correspond to natural vibration of bubbles of 0.01 to 0.02 mm in diameter. This—supported by other observations—makes author conclude that the collapsing cavities break up into several minute bubbles.

A relationship also appears between the maximum bubble diameter, occurring during the growth of the bubble, and wave pressure. M. Nechleba, Czechoslovakia

Incompressible Flow

(See also Revs. 5677, 5706, 5707, 5708, 5742)

Book—5632. Rouse, H., editor, Advanced mechanics of fluids, New York, John Wiley & Sons, Inc., 1959, xiv + 444 pp. $9.75.

Book is a companion volume to "Elementary mechanics of fluids" on an advanced level. Introductory knowledge on the level of the earlier volume is presumed. The new book is the result of a group endeavor by several present and former staff members of the Iowa Institute of Hydraulic Research. The goal is the development of research methods with primary emphasis on the theoretical approach.

The eight chapters deal with: introduction to research in fluid motion (including dimensional considerations), fundamental concepts and equations, principles of irrotational flow, conformal representation of two-dimensional flow, laminar motion, turbulence, boundary layers, free-turbulence shear flow. Many problems of varying difficulty are included in every part of the book, and the solutions are given in an appendix.

Although consisting of contributions by various authors with varied interests and viewpoints, the presentation is surprisingly uniform. The book will be very useful as a modern textbook for students and also for self-instruction.

H. Gortler, Germany

5633. Hasimoto, H., On the periodic fundamental solutions of the Stokes equations and their applications to viscous flow past a cubic array of spheres, *J. Fluid Mech.* **5,** 2, 317–328, Feb. 1959.

Problems of sedimentation require evaluation of drag on small slowly moving particles. Mutual influence of particles makes drag increase as concentration increases, Stokes' formula applying at zero concentration. Method of attack uses Fourier series, requiring regular array of particles, but type of array affects drag only slightly. Difficulty met by previous workers is overcome by properly accounting for mean pressure gradient.

A. C. Pipkin, USA

5634. Corcos, G. M., and Sellars, J. R., On the stability of fully developed flow in a pipe, *J. Fluid Mech.* **5,** 1, 97–112, Jan. 1959.

The eigenvalue problem is treated in part by asymptotic methods and leads to an algebraic relation between the eigenvalue C, the disturbance wavelength $2\pi/\alpha$, and the Reynolds number R. An examination of this relation reveals two families of eigenvalues. For the first, $C \to 1$, and for the second $C \to 0$, as $R \to \infty$. For the latter, a more accurate solution is required and is given. It is found that all eigenvalues yield stable solutions and that for given values of α and R only a finite number of eigenvalues exists. (From authors' summary).

An additional reference on this problem is the recent paper by Sexl and Spielberg [*Acta Phys. Austriaca* **12,** 9–28, 1958]. In regard to the present authors' suggestion (p. 109) that it might be more realistic to consider disturbances having an exponential factor of the form $\exp(-\nu x + i\omega t)$ with ν complex and ω real, reviewer notes that this idea has been examined previously for two-dimensional parallel flows by Battin [Ph.D. Thesis, Massachusetts Institute of Technology, 1951]. D. W. Dunn, Canada

5635. Picha, K. G., and Eckert, E. R. G., Study of the air flow between coaxial disks rotating with arbitrary velocities in an open or enclosed space, Proc. Third U. S. Nat. Congr. Appl. Mech., June 1958; Amer. Soc. Mech. Engrs., 1958, 791–798.

Paper gives an experimental study of the motion induced by two coaxial disks, with or without shroud, for various velocity ratios and spacing. The Reynolds number varies through the transition range. Measurements of the tangential velocity are reported and discussed. The shroud tends to prevent the formation of a "core."

The flow in the boundary layers is determined analytically from the measured flow fields, assuming turbulent boundary layers.

R. Betchov, USA

5636. Howard, L. N., Hydrodynamic stability of a jet, *J. Math. Phys.* **37,** 4, 283–298, Jan. 1959.

Attention is focused upon the lower branch of the neutral stability curve for asymmetric disturbances of the usual pseudo-laminar jet. Limits as Reynolds number $R \to \infty$ are discussed. The approach is novel and apparently successful for the lower branch, the eigenvalue problem of an integral equation derived from the Orr-Sommerfeld equation being solved in power series in terms of wave number, which process J. Moser [*J. Math. Phys.* **37,** 4, 299–304, Jan. 1959] shows to be valid. The wave number for neutral disturbances varies with R^{-3} away from the lowest critical value which is about $R = 4$. A. Powell, USA

5637. Mitkalinnyi, V. I., The determination of the pressure of a gas jet on a furnace wall (in Russian), Proizvodstvo Stali, Moscow, Metallurgizdat, 1956, 212–221; *Ref. Zh. Mekh.* no. 2, 1958, Rev. 1755.

The mean specific pressure exerted by a jet on a plane surface is determined from the quantity of motion of the jet. It is demonstrated that, for the determination of the mean specific pressure on a plane surface, it is sufficient to know the magnitude and direction in the axis of the jet at the surface. In order to determine the area on which the jet exerts a pressure, it is necessary to determine the distance of the surface from the end face of the nozzle. With increasing angle of incidence of the jet, the divergence between the theoretical value of the specific pressure of the jet on the surface and the real pressure determined experimentally will increase; the real value lags behind the calculated value.

V. N. Gusev

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

5638. Holodovsky, G. E., New method of correlating experimental data for the flow of steam-water mixture in vertical pipes (in Russian), *Teploenergetika* no. 7, 68–72, 1957.

Using dimensional analysis and experimental data, an equation is derived which correlates the transportation rates of steam in a steam-water mixtures flowing in unheated, vertical pipes. Experimental data were obtained in the pressure range from 3 to 216 Kg/cm^2 and with pipe diameters varying from 23–76 mm. The equation also correlates data for air-water and mercury liquid-vapor mixtures. All experimental results are correlated within ±8%. N. Zuber, USA

5639. Zwick, S. A., Behavior of small permanent gas bubbles in a liquid. Part I. Isolated bubbles, *J. Math. Phys.* **37,** 3, 246–268, Oct. 1958.

Assumptions are made that surface tension is sufficient to prevent deformation of bubbles by mass and drag effects; field is

isothermal except for variations caused by compression and expansion of bubbles, and liquid is considerably below its boiling point. Problem is reduced by consideration of radial and translational motions separately.

For radial motion, the basic equations with viscosity omitted are formulated for each phase. Boundary conditions at the phase interface are stipulated. Solution of the system permits examination of temperature variations, bubble pressure-volume relation, and the liquid pressure field. Equation for a bubble moving through a viscous fluid is obtained for the translational case from that of a hard sphere. The case of vertical oscillations of the liquid container is considered, and the expression for the attractive force between two neighboring bubbles in such a system evaluated. This result is extended to the influence of a free plane upon a nearby bubble.

The results of the radial analysis indicate that for frequencies of less than 100 cps all but the largest bubbles are isothermal.

Method outlined appears limited in application to practical systems. Author indicates an alternative approach in Part II of paper which may be more suited for application to practical cases [see following review]. H. N. McManus, Jr., USA

5640. Zwick, S. A., Behavior of small permanent gas bubbles in a liquid, Part II, Bubble clouds, *J. Math. Phys.* **37,** 4, 339–353, Jan. 1959.

Motion of a bubble cloud in a liquid subjected to a varying pressure field is considered. In addition to the buoyant force, induced mass, and drag on individual bubbles, induced pressure forces arise between bubbles tending to contract the cloud. Collective image forces on individual bubbles can be of magnitude exceeding the buoyant force. To employ the continuum concept, a statistical approach is used wherein individual bubble types, i.e., identical radii, are considered collectively; the equation of motion is obtained for the liquid by considering the bubble types as a continuous function. Equations for the bubble mixture are then obtained and applied to the rise of bubbles against gravity. For frequencies of pressure pulsations which are not too low, the reduced equations are separated advantageously into mean and oscillatory components. Sonic velocity in bubble mixtures is considered. Application of the study to practical systems is difficult because of the simplifying assumption of "permanent" gas bubbles which ignores evaporation, condensation, dissolution, cavitation, etc., that can be caused by a varying pressure field.

H. N. McManus, Jr., USA

5641. Zwick, S. A., Behavior of small permanent gas bubbles in a liquid, Part III, A forced vibration problem, *J. Math. Phys.* **37,** 4, 354–370, Jan. 1959.

Equations developed in Part II [see preceding review] are used to explain qualitatively the experimental work of Lee and Miesse. Sloshing is ignored in the analysis. One-dimensional analysis is employed to explain several features of the experimental problem. Acoustic depth of the container is shown to be a variable dependent on frequency, pressure, and temperature—all of which alter the volume or number of the bubbles in the mixture. Resort to a three-dimensional system is needed to resolve other experimental findings. Lack of reproducibility in the experiments is attributed to initial microscopic bubble population. The analysis appears to have qualitative usefulness to practical systems.

H. N. McManus, Jr., USA

5642. Elder, J. W., Steady flow through non-uniform gauzes of arbitrary shape, *J. Fluid Mech.* **5,** 3, 355–368, Apr. 1959.

Author considers the steady two-dimentional flow in a parallel channel in which an arbitrarily shaped gauze is placed for the case in which the viscosity can be ignored except in the immediate vicinity of the gauze. The equations are linearized by requiring that departures from uniformity both in the flow and in the gauze parameters be small. A linear relation between the upstream velocity profile, the downstream profile, the shape of the gauze and the gauze parameters is established. The case for the production of a uniform shear and the cases of the flow through linear and parabolic gauzes are considered. The validity of the solution is verified by experiment. G. Sestini, Italy

Compressible Flow (Continuum and Noncontinuum Flow)

(See also Revs. 5512, 5663, 5664, 5665, 5666, 5703, 5710, 5718, 5736, 5754, 5779, 5780, 5797)

5643. Schindler, A., Principal values of aerodynamic coefficients in transonic unsteady two dimensional flow (in French), *Rech. Aero.* no. 63, 29–31, Mar.–Apr. 1958.

5644. Carriere, P., Interaction of external and internal flow at the exit of a reactor at transonic and supersonic flow (in French), C. R. Journées Internationales de Sciences Aéronautiques, Paris, May 27–29, 1957; Paris, ONERA, Part I, 43–69.

5645. Iura, T., and Beder, E., Experimental investigation of a three-dimensional all supersonic diffusing cascade, AFOSR TR 58-132 (Propulsion Res. Corp., Santa Monica, Calif. R-288; ASTIA AD 203 712), 175 pp., May 1958.

A three-dimensional all-supersonic diffusing cascade was designed by the stream-surface-characteristics method and tested in a wind tunnel over the Mach number range 2.2 to 3.0. Stable supersonic flow was established over a wide range of incidence angles.

Chordwise blade-surface static pressures, exit-plane pitot surveys, and schlieren photographs were obtained.

From authors' summary

5646. Sharp, A. W., The supersonic flow past a leading edge separation bubble, *J. Fluid Mech.* **5,** 3, 445–459, Apr. 1959.

The flow field at $M = 1.96$ outside a leading edge separation bubble has been computed in detail by the method of characteristics with the experimental observations on a two-dimensional, square-nosed flat plate forming the initial data. Good agreement was found at the intersection of the network and the bow wave between computed values and those given directly by the shock-wave equations.

From author's summary by J. Lukasiewicz, USA

5647. Stanbrook, A., The flow upstream of finite span spoilers at supersonic speeds, *Aero. Res. Counc. Lond. Curr. Pap.* 427, 9 pp., 1959.

It is suggested that the flow upstream of swept and unswept spoilers in a supersonic stream may be explained in terms of a vortex type of flow. The presence of this type of flow is shown to be consistent with experimental pressure distributions.

From author's summary

5648. Ceresuela, R., Experimental study of a fuselage with high supersonic flow (in French), *Rech. Aéro.* no. 64, 3–11, May–June 1958.

5649. Smith, W. E., and Weatherston, R. C., Studies of a prototype wave superheater facility for hypersonic research, AFOSR TN 58-158 (Cornell Aero. Lab., Inc., Rep. HF-1056-A-1; ASTIA AD 207 244), 115 pp., Dec. 1958.

This report treats the wave superheater, a unique device to produce continuously a supersonic flow of air or other gases at temperatures and pressures needed for realistic hypersonic testing in the laboratory. The fundamental principles of wave superheater design and operation are developed. A prototype, designed to generate 3000 R in air and 5500 R in argon, starting from room temperature, has been built and tested. These temperatures have indeed been produced and the prototype has successfully demonstrated the principles of wave superheater operation.

The unique flow conditions, characterized by homogeneity, purity, and high temperature, pressure, and velocity, that are generated in hypersonic shock tubes and shock tunnels for short periods can be sustained for many seconds in a wave superheater. Many shock tubes are mounted on a rotating drum and fired cyclically in a manner to produce an uninterrupted jet of uncontaminated, superheated gas that is collected and expanded through a nozzle and test section. High jet power and a large mass flow of test gas are thus produced during the blowdown of stored driver gas. The test flow, being at typical shock-tunnel conditions, reproduces the aerophysical phenomena, especially the high heat fluxes, associated with launching, gliding, and re-entering hypersonic vehicles. The wave superheater is adaptable to full-scale materials and structures testing, to high-speed aerodynamic research, and to studies of such basic processes as molecular dissociation and recombination as well as the interaction of electromagnetic radiation with ionized flow.

A helium-driven, preheated wave superheater, larger than the prototype, has been designed conservatively to superheat 4.3 pounds of uncontaminated air per second to 9000 R, or 12 pounds of argon per second to 17,000 R. This facility as well as more advanced designs and their applications are treated in a companion report: Weatherston et al [see following review].

From authors' summary

5650. Weatherston, R. C., Russo, A. L., Smith, W. E., and Marrone, P. V., Gasdynamics of a wave superheater facility for hypersonic research and development, AFOSR TN 59-107 (Cornell Aeronautical Lab., Inc., Rep. AD-1118-A-1; ASTIA AD 210 223), xiii + 133 pp., Feb. 1959.

This report treats the wave superheater, a unique device to produce a continuous, supersonic flow of uncontaminated air or other gases at temperatures and pressures needed for realistic hypersonic testing in the laboratory. The fundamental principles of wave superheater design and operation are developed. In particular, the gas-dynamic and heat transfer aspects of one version, which is designed to generate 9000 R in uncontaminated air, are discussed.

Hypersonic shock tubes and shock tunnels have the unique ability to generate, albeit for short durations, flows characterized by homogeneity, purity, and high temperature, pressure, and velocity. These flow conditions are likewise obtainable in the wave superheater, but for sustained periods counted in seconds.

A prototype wave superheater has been built and operated successfully at its designed conditions of 3000 R in air and 5500 R in argon, starting from room temperature [see W. E. Smith and R. C. Weatherston, preceding review]. The 9000 R superheater described herein utilizes preheated helium driver and preheated test gases and can superheat 4.3 pounds of uncontaminated air per second at 200 atmospheres stagnation pressure. Argon can readily be substituted for air as a test gas and superheated to 17,000 R at the rate of 12 pounds per second. Cooling of the superheater structure and the effects of heat transfer within the superheated air are examined in detail. Certain shock tube experiments were performed to test the nonsteady heat transfer theory in the range of interest.

The techniques developed in this report for superheating air to 9000 R can be extended to more advanced, higher temperature wave superheater, e.g., one using hydrogen drive. Engineering design of the 9000 R wave superheater and its auxiliary equipment is the subject of a companion report: J. Carpenter, Engineering design of a wave superheater facility for hypersonic research and development, CAL Rep. no. AD-1118-A-2, AFOSR TN 59-108, ASTIA AD 210 224, Feb. 1959.

From authors' summary

5651. Talbot, L., Shaaf, S. A., and Hurlbut, F. C., Pressure distributions on blunt-nosed cones in low density hypersonic flow, *Jet Propulsion* **28,** 12, 832–834 (Tech. Notes), Dec. 1958.

5652. Chernyi, G. G., Hypersonic flow around a slender blunt cone (in Russian), *Dokladi Akad. Nauk SSSR (N.S.)* **115,** 4, 681–683, 1957. (Translated from Russian by M. D. Friedman, P. O. Box 35, West Newton, Mass., C-113, 5 pp.).

In a former paper [*Dokladi Akad. Nauk SSSR (N.S.)* **114,** no. 4, 1957; AMR **12** (1959), Rev. 1384], author formulated the general problem of the hypersonic gas flow around a slender blunted body of revolution or profile and has given its approximate solution for the case of the flow around a blunt wedge. In this paper the solution of the problem of the flow around a blunt cone is communicated in the same approximate formulation and a comparison is made between the mathematical solution computed for the asymptotic form (i.e., neglecting initial pressure) and experimental results (for a cone with the semivertex angle 10° and for various bluntnesses at Mach number 6.85). The results show qualitative agreement.

It may be mentioned that on the condition of symmetric incident flow, author, according to his basic hypothesis and using a certain law of plane sections, reduces the problem to an equivalent one of one-dimensional unsteady gas motion with cylindrical waves.

M. Schaefer, Germany

5653. Gonor, A. L., and Chernyi, G. G., On minimum drag bodies at hypersonic speeds (in Russian), *Izv. Akad. Nauk SSSR, Otd. Tekh. Nauk* no. 7, 89–93, 1957 (Translated from Russian by M. D. Friedman, P. O. Box 35, West Newton, Mass., G-141, 6 pp.).

This investigation is based on a formula for the pressure on the surface of axisymmetric bodies or planar profiles, respectively, which formerly has been established by the second author neglecting terms of order $(\gamma - 1/\gamma + 1)$ (γ ratio of specific heats) and which had already been obtained (1933) by A. Busemann by another method. This formula gives an expression for the drag coefficient and, using this expression, the variational problem of finding the shape of the minimum drag body under various additional conditions can be solved. This shape is determined for given parameter values of both the radii of an annular area.

A comparison is made of the drag coefficients of a body of optimum shape with the drag coefficients of cones. It follows that the transition from a cone to such a body decreases the drag by a 30% order of magnitude. An interesting circumstance is that the generator of a body of revolution with minimum drag for a given length is almost the shape of the curve in linear supersonic gas flow theory. Hence it can be expected that bodies with a small relative thickness will be almost minimum drag bodies in a wide range of supersonic flight speeds.

M. Schaefer, Germany

5654. Napolitano, L. G., Introduction to the study of aerothermochemistry (in Italian), *Aerotecnica* **38,** 2, 96–108, Apr. 1958.

Author studies the general equations of motion governing a binary mixture of perfect gases in the presence of chemical reactions. Nondimensional terms are introduced and the equations are analyzed in terms of the basic parameters. Order-of-magnitude studies with various assumptions as to the relative effect of macroscopic and microscopic scales of mechanical phenomena and of chemical phenomena lead to simplified sets of equations. In particular, equations are obtained which correspond to $M^2 \ll 1$, $M^2 = 0(1)$, and, for dissipative motions, to boundary layers.

These equations are studied in general terms; for the supersonic case the equations for the characteristics are obtained; for the dissipative case, the Crocco and Busemann integrals are shown to be valid under appropriate conditions; and for nondissipative, steady flows a study is made of the effect of the chemical reaction terms on such fundamental theorems as the variation of enthalpy and entropy along streamlines, the Bernoulli equation, and Crocco theorem. P. Chiarulli, USA

5655. Feldman, S., On the existence of recombination shocks, *Physics of Fluids* **1,** 6, p. 546 (Letters to the Editor), Nov./Dec. 1958.

5656. Duff, R. E., Laminar boundary layer development behind shock waves in argon, *Physics of Fluids* **1,** 6, 546–547 (Letters to the Editor), Nov./Dec. 1958.

5657. Friend, W. H., The interaction of a plane shock wave with an inclined perforated plate, Univ. Toronto, Inst. Aerophys. TN 25, 50 pp., Oct. 1958.

The interaction of a plane shock wave with an inclined perforated plate has been studied experimentally in a shock tube. Four 1/8 inch thick steel plates of 50% blockage were used, with an incidence range of 45 to 90 degrees, in 15 degree intervals, and an incident shock pressure ratio range of 2 to 12 in intervals of 2. The two-dimensional interaction was recorded on shadow and schlieren photographs. Weak incident shock waves produced two main wave elements, the reflected and transmitted shock waves, and a turbulent contact surface. Strong incident shock waves caused choked flow at the minimum plate cross section, and a supersonic region downstream of the plate terminated by an additional travelling shock wave. The calculated results for the transmitted, reflected, and auxiliary shock strengths and their inclinations, as well as the predicted critical flow choking Mach number and contact front inclination are in good agreement with the experimental results. From author's summary

5658. Christensen, Daphne, and Buhler, R. D., On the stable shape of an ablating graphite body, *J. Aero/Space Sci.* **26,** 1, p. 54 (Readers' Forum), Jan. 1959.

5659. Schamberg, R., A new analytic representation of surface interaction for hyperthermal free-molecule flow with application to satellite drag, Heat Transf. and Fluid Mech. Inst., Univ. Calif., Los Angeles, Calif., June 1959, 1–14.

Usual model of surface interaction involving reflection and accommodation coefficients is replaced by one in which the reflected molecules lie in a beam whose width and angle are parameters. The velocity of reflected particles is, lacking data, assumed uniform and described by the usual accommodation coefficient. The model is claimed to be more realistic than the usual one. While probably true, reviewer doubts that improved drag predictions are likely to result since the model is still rather arbitrary and the required experimental determination of the parameters involved is not now available. Using this model in the limiting case of high velocity, simple expressions for the drag of simple bodies are found.

The remainder of the paper is concerned with errors in satellite drag calculation; and while the above-described model is used, the results don't particularly depend on its use. Conclusions are that the nature of the surface interaction is more important than the geometry; that the accommodation coefficient is more important than the mean direction of re-emitted molecules; and that atmospheric composition is relatively unimportant. The case of a tumbling satellite is also examined.

S. H. Maslen, USA

5660. Teipel, J., A new characteristic procedure for one-dimensional unsteady flow (in German), *Dtsch. Versuchsanstalt Luftfahrt Ber.* 74, 38 pp., Aug. 1958.

A new practical calculation procedure of the characteristic method for one-dimensional unsteady flow in a nozzle with variable cross-sectional area has been developed for both isentropic and anisentropic cases. Some numerical examples are given. This procedure is much easier to work with than the conventional method and should be interesting to engineers working in such problems. S. I. Pai, USA

Boundary Layer

(See also Revs. 5634, 5635, 5656, 5674, 5709, 5715, 5743, 5752, 5753)

5661. Matting, F. W., Chapman, D. R., Nyholm, J. R., and Thomas, A. G., Turbulent skin friction at high Mach numbers and Reynolds numbers, Heat Transf. and Fluid Mech. Inst., Univ. Calif., Los Angeles, Calif., June 1959, 80–94.

Results are presented of local skin-friction measurements in turbulent boundary layers over a Mach number range from 0.2 to 9.9 and at Reynolds numbers up to 100×10^6. Direct force measurements were made by means of a floating element in a smooth flat surface. The flow conditions were two-dimensional with essentially zero pressure gradient and with adiabatic conditions at the wall. Air and helium were used as working fluids. An equivalence parameter for comparing different working fluids in the boundary layer is derived and the experimental verification of the parameter is demonstrated. Experimental results are compared with the results obtained by several methods of calculating skin friction in the turbulent boundary layer. Several boundary-layer surveys with a pitot probe were made in air and helium at the Mach numbers at which skin-friction measurements were made. At the two hypersonic Mach numbers investigated, the velocity gradient near the wall as deduced from the pitot-probe surveys was in noticeable disagreement with the gradient deduced from the skin-friction measurements. Some possible reasons for this discrepancy are discussed.

From authors' summary by M. J. Goglia, USA

5662. Kudryashev, L. I., and Teverovsky, B. M., Some new forms of generalized integral equations for the hydrodynamic and thermal boundary layers (in Russian), *Trudf Kuibyshevsk. Aviats. In-ta* no. 3, 3–9, 1957; *Ref. Zh. Mekh.* no. 2, 1958, Rev. 1964.

An integral equation is derived for the unsteady flow in an axially-symmetrical boundary layer, which is analogous to the Feinsilber relationship for the two-dimensional case, which is itself a generalization of von Karman's well-known integral equation. A similar integral relationship is also set up for the case of a thermal boundary layer. B. N. Rumyantsev

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

5663. Curle, N., The steady compressible laminar boundary layer, with arbitrary pressure gradient and uniform wall temperature, *Proc. Roy. Soc. Lond.* (*A*) **249,** 1257, 206–224, Jan. 1959.

An approximate integral of the energy equation is derived by expressing the total temperature as a quadratic function of velocity, the Prandtl number being taken as unity. The three coefficients are chosen to satisfy the two temperature boundary conditions and to give the correct temperature profile in the outer part of the boundary layer.

A transformation of the normal co-ordinate is applied, which partially reduces the momentum equation to an incompressible form. In the transformed co-ordinates the functional relationships

between the skin friction, pressure gradient and shape parameters should be approximately given by their incompressible forms, the effects of compressibility appearing explicitly in certain additional terms in the equation and implicitly in the transformation. Using these correlations, together with the approximate temperature profile, the momentum equation is reduced to a form whose integration requires only two quadratures. The predictions of the theory are compared with three exact solutions. The error in the predicted separation position increases with Mach number and is about 20 and 40% at Mach numbers of 3 and 4, respectively.

From author's summary by J. C. Rotta, Germany

5664. Epstein, M., The three-dimensional compressible laminar boundary layer, AFOSR TN 58-894 (Polyt. Inst. Brooklyn, Aero. Lab. Rep. 455; ASTIA AD 204 135), 77 pp., Oct. 1958.

After a concise review of published work on the subject stated in the title, author attacks the problem assuming perfect gas, unit Prandtl number, constant wall temperature, viscosity proportional to temperature, and irrotational outer flow. Certain transformations of variables are introduced in order to make the equations resemble those of incompressible flow. The method of solution used here is demonstrated by its application to the incompressible plane-flow boundary layer: an approximate shear profile is assumed, involving a parameter; the indefinite integral of the momentum equation with respect to the normal coordinate, together with a boundary condition, then yields a second approximation to the shear profile, etc. This procedure is tested by application to classical cases.

To extend this to three-dimensional compressible flow one must assume two shear profiles and a heat-transfer profile. The problem is reduced to solving a set of three first-order differential equations. This procedure is tested by comparison of results with those of Cohen and Reshotko for similar, two-dimensional, compressible flow [*NACA Rep.* 1293 (1956); see AMR **8** (1955), Rev. 2807] and those of Reshotko and Beckwith for yawed infinite cylinders [*NACA TN* 3986 (1957); AMR **11** (1958), Rev. 216]. It is concluded that the method is superior to conventional (Kármán-Pohlhausen) integral methods. The iterations, however, involve very lengthy expressions and are not carried beyond the second approximation, as defined above. Finally the theory is applied to a certain highly sweptback wing with curved leading edge (a "Ferri-sled") for which the pressure distribution has been measured at Mach number 3.09. Results are compared with those of Vaglio-Laurin [*WADC TN* 58-147; AMR **12** (1958), Rev. 5112], which were based on a hypersonic approximation.

W. R. Sears, USA

5665. Meksyn, D., The boundary layer equations of compressible flow separation (in English), *ZAMM* **38,** 9/10, 372–379, Sept./Oct. 1958.

By a number of transformations of the axial and normal coordinates (x, y), author converts equations of momentum, continuity, state and thermal energy into two partial differential equations for the velocity and temperature functions in the compressible laminar boundary layer. Pressure gradient and (constant) Prandtl Number σ are arbitrary, while $\mu \sim T^{\varepsilon}$. For the case of $\varepsilon = 1$, $\sigma = 1$ and no heat transfer, a single partial differential equation, similar to that corresponding to incompressible flow is obtained. (The present transformation and final equations are somewhat different from Stewartson's.) This equation is then solved (by a series method) for flow past a semi-infinite plane with separation induced by a shock wave. An experimental velocity distribution at the outer edge of the boundary layer is assumed, and emphasis is placed on determination of the separation point.

Misprints noted: In Eq. [6.1], "$f(\eta_1\alpha)''_{\eta}$" should read "$f(\eta, \alpha)$". On top of p. 375, equation should read $p\rho_1^{-\gamma} = \text{const}$. In the entire text after Eq. [4.2], the symbol "S" apparently denotes the quantity "ζ" in the equations.

M. Morduchow, USA

5666. Laufer, J., and Vrebalovich, T., Experiments on the instability of a supersonic boundary layer (in English), 9th Congrès Intern. Mécan. Appl., Univ. Bruxelles, 1957; **4,** 121–131.

Article is a first report of investigations of supersonic boundary-layer stability. A specially constructed siren introduced disturbances on a flat plate at Mach numbers near 2. Damping or growth of disturbances of various frequencies was measured by hot wire. Unstable disturbances of wavelike type were definitely found; and approximate stability boundaries were established. Experimentally measured boundaries do not check theoretical values very well, except qualitatively. The complete investigation is now available as Report No. 20-116 of the Jet Propulsion Lab, California Institute of Technology.

A. M. O. Smith, USA

5667. Shestopalov, V. P., Nonlinear theory for a laminar boundary layer of a viscous compressible liquid (in Russian), *Uch. Zap. Khar'kovsk. Gos. Ped. In-ta* **18,** 113–120, 1956; *Ref. Zh. Mekh.* no. 11, 1957, Rev. 12803.

A short exposition is furnished of the case of the nonlinear theory for a viscous compressible liquid, based on the fact that the tensor of the stresses is a quadratic function of the tensor of the velocities of deformation. The generalized equations for the motion and for the heat transfer are recorded. Author takes the boundary layer as the zone of application of these equations, for it is in this layer that large gradients of velocity and temperature may be formed and where the linear relation of the stress tensor to the tensor of deformation velocity may be destroyed; the boundary layer being situated here as the basis of the customary theory of a viscous liquid. The equations for a plane laminar boundary layer, obtained on the basis of the nonlinear theory of a viscous liquid, are distinguished from the usual equations by the presence in both equations of the motion of the term $\dfrac{\partial}{\partial y}\left(\mu^* \dfrac{\partial u}{\partial y}\right)$ where μ^* is the coefficient of viscosity. Owing to this, $\partial p/\partial y \neq 0$ in the boundary layer. The equations of continuity and energy transfer remain the same as before. The practical importance of the nonlinear theory ought to be experimentally established.

V. A. Sukhnev

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

5668. Tani, I., and Sato, H., Boundary-layer transition by roughness element (in English), 9th Congrès Intern. Mécan. Appl., Univ. Bruxelles, 1957; **4,** 86–93.

The transition due to a two-dimensional roughness element (a cylindrical wire) on a flat plate in a low-turbulence wind tunnel was studied. A hot-wire anemometer was used for measuring the mean velocity and the longitudinal velocity fluctuation. The transition is of different types according as the height of the roughness element is small or large compared with the thickness of the boundary layer. With a given roughness element placed on a plate at a given distance from the leading edge the transition point moves gradually forward and the transition Reynolds number (based on the boundary-layer thickness at the transition point) decreases, if the free-stream velocity is increased. At a certain size of the roughness element the transition point reaches the element and the transition Reynolds number begins to increase as the free-stream velocity is further increased. The minimum of the transition Reynolds number approximately corresponds to the demarcation of the two types of transition.

E. Petersohn, Sweden

5669. Schultz-Grunow, F., Influence of a single roughness in laminar and turbulent boundary layers (in English), 9th Congrès Intern. Mécan. Appl., Univ. Bruxelles, 1957; **4,** 201–212.

Purpose of article is to analyze and describe in detail the flow about a single roughness in a boundary layer. The roughness is

treated as an object in a shear flow, and an analytic solution for such a flow about a circular cylinder in contact with the wall is obtained. Several photographs of the boundary-layer flow past a simulated roughness are included, which clarify the process by which a roughness affects transition. A new flow visualization technique was used which makes use of a sort of paint as the test medium. A. M. O. Smith, USA

5670. Whitehead, L. G., Cheers, F., and Mandl, P., Flow about aerofoils with split flaps with application to circulation control by suction, *Nat. Aero. Establ., Canada, Lab. Rep.* 226, 75 pp., Apr. 1958.

In the first part the potential flow around a two-dimensional airfoil with a split flap is calculated by means of conformal transformation. To fulfil the Kutta conditions at the trailing edge of the airfoil and at the tip of the flap, a source is placed at the point where the split flap is connected to the airfoil. The source flow can be regarded as a rough approximation to the flow in the separated region between the airfoil and the flap and in the wake.

In the second part the problem is extended to a two-dimensional airfoil with a split flap with a suction slot on the upper surface of the flap. The suction slot is idealized by a single sink. The calculations give large increase of lift, but comparisons with experimental results, carried out in the Montreal Road Laboratories water tunnel, are not very good. The treated problem is too complicated to get good results by neglecting viscosity effects. Furthermore, in practice suction is usually applied to control the boundary layer, not to change the nonviscous outer flow past the airfoil. K. Gersten, Germany

5671. Lin, C. C., Motion in the boundary layer with a rapidly oscillating external flow (in English), 9th Congrès Intern. Mécan. Appl., Univ. Bruxelles, 1957; **4,** 155–167.

The motion inside the boundary layer caused by a rapidly oscillating main stream is studied by an approximate analysis. The basis of the approximation is briefly as follows: If the time-frequency of the oscillation is very high, the local acceleration is very much larger than the time-dependent part of the convection of momentum. Thus the time-dependent part of the motion becomes a linear one, which is closely related to the Rayleigh problem of the oscillating infinite plate.

To include the higher harmonics of the oscillatory motion, an iteration procedure is suggested. L. N. Tao, USA

Turbulence

(See also Revs. 5668, 5777, 5801, 5832)

5672. Batchelor, G. K., Small-scale variation of convected quantities like temperature in turbulent fluid. Part I. General discussion and the case of small conductivity, *J. Fluid Mech.* **5,** 1, 113–133, Jan. 1959.

Paper describes a theoretical investigation of the form of spectrum at large wave numbers of temperature, concentration of solute or like scalar quantity θ in a turbulent field. Hypotheses similar to those made by Kolmogoroff for the small-scale variations of velocity are assumed to apply also to the small-scale variations of θ. In this spectral range the velocity fluctuations can be described by two quantities ε, the rate of viscous dissipation, and ν, the kinematic viscosity, and θ variations by the analagous quantities χ, the rate of destruction of θ^2 and κ, a diffusivity. The Reynolds number of the turbulence is assumed large enough that an equilibrium range exists wherein, as has been previously shown, the spectrum of velocity fluctuation varies as $n^{-5/3}$ (n being wave number). For low wave numbers in this range it has also been shown that the θ spectrum has the same variation.

Two cases are considered. For high conductivity, $\kappa >> \nu$, there exists a conduction cut-off near $n = (\varepsilon/\kappa^3)^{1/4}$ beyond which the θ spectrum is affected by the rapid dissipation of thermal fluctuations tions (see following review). For low conductivity $\kappa << \nu$, the conduction cut-off occurs at higher wave numbers near $n = (\varepsilon/\nu\kappa^2)^{1/4}$ and there exists a subrange between the two cutoffs in which the rapid dissipation of velocity fluctuation affects the θ spectrum. Author studies spectral form for this latter subrange by analyzing the effect of the velocity field, assumed to be a uniform straining motion, and of κ on a single Fourier component of θ. The wave number is changed (generally increased) by the straining motion and the amplitude is decreased by diffusion. The end result is a variation of the θ spectrum with n^{-1}.

Throughout the paper, the relationship of this work to that of previous investigations is discussed. Author explains confusion of previous results. W. D. Baines, Canada

5673. Batchelor, G. K., Howells, I. D., and Townsend, A. A., Small-scale variation of convected quantities like temperature in turbulent fluid. Part 2. The case of large conductivity, *J. Fluid. Mech.* **5,** 1, 134–139, Jan 1959.

Analysis of paper in foregoing review is extended to case in which conductivity is large compared with the viscosity. In this case conduction cut-off of θ-spectrum occurs at wave number smaller than that for viscosity cut-off of velocity spectrum. A plausible and consistent hypothesis is advanced whereby the form of the θ spectrum may be computed in the subrange between the two cut-offs. The result is a variation of spectrum with $n^{-17/3}$. The way in which conduction influences the effect of connection on the distribution of θ at these wave numbers is discussed.

From authors' summary by W. D. Baines, Canada

5674. Shigemitsu, Y., Non-similarity theory of decaying turbulence, *J. Phys. Soc. Japan* **14,** 1, 91–103, Jan. 1959.

Author's theory of turbulent motion as a chaotic assembly of vortices is extended to the case of decaying turbulence by considering the development of a cascade of vortices from an initial state of eddies of a single type. Eddies of any particular size generate smaller eddies at a rate proportional to their number and at the same time all the eddies decay in intensity and grow in size at rates given by the Navier-Stokes equations for a single eddy of the type concerned. Using this representation of the transfer process, the decay of turbulent intensity and the development of the correlation function from the assumed initial conditions are computed and compared with experiment. The agreement is fairly good in broad outline but some of the details are inconsistent with the measured characteristics of grid turbulence; e.g. the computed transverse correlation function does not take negative values.

A. A. Townsend, England

5675. Pischanenko, V. V., An examination of the dynamics of turbulence in a shallow, cylindrical chamber with a diametrally-directed, axially-symmetrical jet (in Russian), *Nauchn. Trudi Odessk. Vyssb. Morekbodn. Uch-sbcba* no. 2, 12–31, 1956; *Ref. Zb. Mekb.* no. 2, 1958, Rev. 1761.

For the complete and correctly-timed combustion of a fuel in a combustion chamber a degree of turbulence is required at which the eddies formed in the chamber during the injection period have time to produce a complete change of air. The case is investigated of a flat, cylindrical chamber, with a diametrally-directed, axially-symmetrical jet issuing from a nozzle arranged on the periphery of the chamber. The known relationships of the theory of free, turbulent jets are applied to the determination of the parameters of the flow at the outlet from the nozzle, determining the necessary degree of turbulence. Expressions are obtained for determining the magnitude of the necessary flow volume at the exit from the nozzle from

given parameters of the working cycle and dimensions of the engine.

V. N. Gusev

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

5676. Lyshevsky, A. S., The influence of turbulence on the disintegration of a fluid jet (in Russian), *Nauchn. Tr. Novocherkassky Politekhn. In-ta* **39**, 53, 81–86, 1957; *Ref. Zh. Mekh.* no. 2, 1958, Rev. 1840.

Paper analyzes the findings of various authors who have investigated the characteristics of fluid flow in the jet nozzles of burners for atomized fuels. By suitable treatment of the nondimensional parameters of experimental data on the length of the undisturbed jet, obtained by a number of research workers, the following formulas have been derived:

$$\frac{l}{d_c} = cW^{-m}R^{-n}, \qquad W = \frac{u_c^2 \rho_m d_c}{\alpha}, \qquad R = \frac{u_c d_c}{\nu_m}$$

where l is length of undisturbed length of jet; d_c diameter of nozzle aperature, u_c velocity of issuing fuel jet; ρ_m, ν_m density and coefficient of kinematic viscosity of the fuel, α coefficient of surface tension of the fuel. Values are cited for the coefficient c and the exponents m and n for three sections, according to the R number, corresponding to three states of outflow of the fuel from the nozzle aperture: laminar ($c = 8.22 \times 10^4$, $m = 0.4$, $n = 0.268$); transitional ($c = 6.91 \times 10^5$, $m = 0.4$, $n = 0.546$), and turbulent ($c = 1.4 \times 10^7$, $m = 0.4$, $n = 0.933$). It is concluded that turbulence is one of the causes of the disintegration of fluid jets.

Yu. F. Dityakin

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

5677. Lyshevsky, A. S., The problem of the coefficient of free turbulence in a jet of atomized liquid fuel (in Russian), *Trudi Novocherkas. Politekhn. In-ta* no. 33/47, 239–248, 1956; *Ref. Zh. Mekh.* no. 2, 1958, Rev. 1992.

An approximate method is proposed for determining the coefficient of free turbulence of a jet of atomized fuel required for constructing the concentration fields of the liquid. The analysis is founded on the theory of the turbulent gas jet developed by G. N. Abramovich ["The turbulent free jets of liquids and gases," Energoizdat, 1948], with allowance for the phenomenon of dissipation of the jet. Using the method of dimensional analysis the experimental data of Miller and Birdsley are analyzed in nondimensional parameters, and a relationship is obtained between the coefficient of free turbulence of the jet and the air density and outflow characteristics of the fuel.

K. N. Erastov

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

5678. Fel'zenbaum, A. I., A study of the eddy motions of a liquid by the methods of the theory of analytical functions with an ideal number of special points (in Russian), *Vestnik Mosk. In-ta* no. 1, 17–22, 1956; *Ref. Zh. Mekh.* no. 10, 1957, Rev. 11534.

Let Σ be a finite plane region filled with eddies and S a region inside Σ, equal in area to Σ, but consisting of an ideal universally discontinuous multiplicity of points. Author determined the consistency of the eddies γ at points of the multiplicity S ($\gamma = 0$ inside the multiplicity S) and produces the function

$$u(z) = \frac{1}{2\pi i} \iint_S \gamma(t) \ln (z - t) dS$$

where z is a point externally situated to S. It is shown that $u(z)$ possesses all the properties of a complex potential. Calculations are made for the lifting power and for the moment of an arbitrary profile.

I. S. Arzhanykh

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

5679. Ogura, Y., On the isotropy of large-scale disturbances in the upper troposphere, *J. Meteorol.* **15**, 4, 375–382, Aug. 1958.

An analysis is made of one-dimensional variance and cross-spectra of the two horizontal wind components as presented by Benton and Kahn. Besides the $-5/3$ power law, the theoretical relation between the $\overline{u^2}$ and $\overline{v^2}$ spectra are tested. A correction is introduced with respect to the geostrophic approximation. It appears that the requirement for isotropy is satisfied at lat. 20 N and 70 N. In the region between lat. 30 N and 60 N, the variance of the north-south component is too large with respect to the variance of the east-west component for isotropy. The wavelengths analyzed lie between 60 deg and 20 deg of longitude.

J. A. Businger, USA

Aerodynamics

(See Revs. 5537, 5629, 5653, 5670, 5690, 5691, 5705, 5717, 5719, 5783)

Vibration and Wave Motion in Fluids

(See also Revs. 5744, 5832)

5680. Phillips, O. M., The equilibrium range in the spectrum of wind-generated waves, *J. Fluid Mech.* **4**, 4, 426–434, Aug. 1958.

Author considers a nonlinear random surface wave model of unspecified probability distribution. Problem investigated is the nature of the wave spectrum in the equilibrium range of spectral frequencies, where components attain fixed energy levels indepedent of wind parameters. Assumption is that wind fetch and duration are large enough to permit components of finite amplitude and consequent interactions between them.

From qualitative evidence on wave behavior author reasons that the equilibrium state is connected with the existence of sharp crests in shorter wave components, and subsequent detachment of these crests accompanied by whitecaps. It is suggested that the limiting condition for equilibrium in this high-frequency range is such that the downward acceleration of the fluid at the crest is equal to g, the acceleration of gravity. If acceleration exceeds g, fluid is under tension and crest detaches.

Dimensional analysis is then invoked to eliminate all physical parameters except g, together with the frequency ω or the wave number K, as relevant to the problem. It then follows dimensionally that the equilibrium spectrum at a fixed point is $\phi(\omega) \cong \alpha g^2 \omega^{-5}$, where α is a constant, and that the instantaneous spatial spectrum $\bar{\psi}(K)$ is proportional to K^{-4} for large wave number K.

Reviewer believes paper to be significant contribution, and that considerable evidence exists to support author's result. Precise measurements, limited to the high-frequency range, made by Burling [Ph.D. Dissertation, Univ. of London, 1955] and Hicks and Huber [*Physics of Fluids* **1**, 5, Sept.–Oct. 1958] yield spectral relationship of type suggested by author. Spectra suggested by various researchers covering entire surface wave frequency range show considerable variation, especially at low frequencies. This might be expected, since such spectra were generally developed employing linear considerations along with observations in which lower frequencies predominate. Several of these spectra, however, reduce to author's spectrum at high frequencies.

Author states that little evidence is available which indicates the lowest frequency at which nonlinear effects are appreciable and his spectrum holds. More recently, Tick [N.Y.U. Stat. Lab. Sci. Paper no. 11, Oct. 1958] has evaluated the nonlinear wave

spectrum to the second order of approximation. The results indicate that nonlinear effects are important for those frequencies greater than twice the frequency at the energy peak.

J. J. Schule, USA

5681. Fomichev, M. S., Study of the hydrodynamics of submerged hydraulic jump, *Soviet Phys.-Tech. Phys.* **3,** 8, 1671–1680, Mar. 1959. (Translation of *Zh. Tekh. Fiz., Akad. Nauk SSSR* **28,** 8, 1813–1822, Aug. 1958 by Amer. Inst. Phys., Inc., New York, N.Y.)

This paper presents new data regarding the kinematic structure of real flow, the distribution of the fluctuations of the hydrodynamic pressure at its boundary, and the development of the rules of similarity of the kinematic and dynamic characteristics of a flow, flowing over a weir, with the understanding that the problem is two-dimensional, with a submerged hydraulic jump.

From author's summary

5682. Escande, L., Water hammer caused by instantaneous closure in a multiple characteristic pipe (in French), *Houille Blanche* **13,** no. A, 377–384, July 1958.

This investigation of the maximum amplitude of overpressures and depressions resulting from complete instantaneous closure in a multiple characteristic pipe produces higher values than those one would expect to get by considering a single section of pipe and introducing maximum flow speed and wave speed, which would, however, seem to be the most attractive procedure on first sight.

From author's summary

5683. Hayashi, T., Dynamical similtude of surge tanks (in Japanese), *Trans. Japan Soc. Civ. Engrs.* no. 61, 1–21, Mar. 1959.

An extension is presented of the dynamical similtude of model tests of surge tanks for the most general case. Additional conditions to be imposed [for dynamical similitude] and the modification of the similitude for preliminary design purposes are examined in detail. Model tests for several selected complicated cases are made to determine whether dynamical similitude can still exist in such complicated cases. The surging waves worked out by arithmetical integration of the surging equations are compared with the results according to the similtude of the surging waves obtained with the model. The agreement in every case is satisfactorily close, indicating that dynamical similitude is always reliable for model tests of any complicated case.

From author's summary

Courtesy, Editorial Committee of the Japan Society of Civil Engineers

5684. Samuels, J. C., On propagation of waves in slightly rough ducts, *J. Acoust. Soc. Amer.* **31,** 3, 319–325, Mar. 1959.

Previous work has treated rectangular waveguides with one rough surface. Author extends theory to duct with two parallel rough surfaces. Acoustic solution is found to second approximation, and electromagnetic to first (for TE waves). In both, first approximation is examined for effects of sinusoidal, harmonic, and random roughness, and roughness with exponential correlation function. For sinusoidal and harmonic roughness, limiting frequencies are found above which perturbation due to roughness is not propagated upstream. Author also calculates frequencies at which fluctuation is amplified, suggesting use in a novel comb filter.

V. Salmon, USA

5685. Becker, E., Surface wave configuration of a stream where a pulsating source is situated in a heavy liquid under the surface (in German), *ZAMM* **38,** 9/10, 391–399, Sept./Oct. 1958.

A harmonic point source of liquid is placed at some distance below surface of stream of heavy, incompressible, nonviscid liquid of arbitrary depth. Neglecting effect of surface tension and generalizing author's earlier treatment of (simpler) two-dimensional case of line source [AMR **9** (1956), Rev. 3301], a simple geometric construction is presented for the curves of constant phase (such as the wave crests) on the liquid surface, taking into account the general dependence of the phase speed upon the wave length (dispersion). Construction is asymptotically correct for large distance from source. Author shows from above construction that the energy is radiated radially outward from the source, and he also derives parametric equations for the curves of constant phase. The special case of a liquid of infinite depth, treated earlier (by use of the method of stationary phase) by L. N. Sretenskiĭ [AMR **8** (1955), Rev. 2768], is considered. The construction of the curves of constant phase for capillary waves is sketched.

R. Heller, USA

5686. Evangelisti, G., On the power furnished in unsteady liquid flow in an elastic tube (in Italian), *Atti Accad. Naz. Lincei, R.C. Cl. Sci. Fis. Mat. Nat.* (8) **24,** 3, 287–290, Mar. 1958.

When inviscid liquid flows through an elastic tube to emerge into the air through a small orifice whose area can be varied (cf. the hydraulic ram), power furnished in some cases increases, in others decreases, when the efflux increases. This apparent paradox is explained by a specific formula which shows that variations of power furnished and efflux are in the same or opposite senses according to whether the ratio of kinetic to elastic energy is greater or less than unity.

L. M. Milne-Thomson, USA

5687. Edge, P. M., Jr., Hydrodynamic impact-load alleviation with a penetrating hydro-ski, *NASA Memo.* 1-9-59L, 31 pp., Feb. 1959.

A series of impacts at fixed trim angles were made in smooth and rough water at the Langley impact basin with a hydro-ski having a beam-loading coefficient of 111 mounted beneath a model having a beam-loading coefficient of 3.6. The impact-loads data are presented and are compared with data obtained from similar impacts of the model without the hydro-ski. Flow and cavity generation by the hydro-ski are discussed and illustrated with stereophotographs.

From author's summary

Fluid Machinery

(See also Revs. 5491, 5492, 5645, 5716)

Book—5688. Matheson, W. G., edited by, Fourth national symposium on vacuum technology—transactions (Boston, Mass., Oct. 1957), New York, Pergamon Press, 1958, 176 pp. $12.50.

This bound volume of papers deals with the current state of the art in several phases of high vacuum technology. Book is divided into three sections: (1) Scientific basis of vacuum techniques and their application to scientific and applied research. (2) Methods and techniques for obtaining and measuring high vacuum and ultra-high vacuum industrial applications. (3) Industrial Applications.

Included are general articles on developments in Roots-type blowers, steam ejectors, oil diffusion pumps and getter-ion pumps. Vacuum pumping technology for both scientific and industrial vacuum systems of large size is covered. There are also papers on vacuum seals, and vacuum-measuring and leak-detecting instrumentation.

Major portion of book is devoted to industrial vacuum technology. Some topics covered are: Vacuum drying, theory and practice of vacuum metallizing, metal evaporation and vacuum metallurgy. Included in articles on vacuum metallurgy are papers on stream de-gassing, heat treating and melting processes.

Persons interested in brief surveys of specific phases of current industrial vacuum technology will find this book to be of value. It is not intended to be a textbook on modern industrial and scientific vacuum techniques.

T. P. Clark, USA

5689. Le Manach, J., and Robert, E., Contribution to the visualization and study of flow in cascades of airfoils of centrifugal compressors at low Mach number (in French), *Recb. Aéro.* no. 67, 21-34, Nov./Dec. 1958.

5690. Abe, S., Research on hydrofoil profiles suitable for a straight cascade of accelerated flow, Rep. 1. Theoretical study (in English), *Rep. Inst. High Speed Mech., Tohoku Univ.* **9**, 81/90, 105-118, 1958.

A theoretical method is presented for calculating a profile with given surface pressure distribution in an accelerated flow through cascade in which the movement of the pressure center is small. The calculation is based on successive approximation of the fundamental equation of cascade flow used by the author in previous studies.

Two examples are given with profiles having thickness ratio 8% and 4%, and the results are compared with corresponding Clark Y-type profiles. K. Pilarczyk, USA

5691. Abe, S., Research on hydrofoil profiles suitable for straight cascade of accelerated flow. Rep. 2. Experimental study (in English), *Rep. Inst. High Speed Mech., Tohoku Univ.* **9**, 81/90, 119-134, 1958.

Results are presented of cascade tests with one of the profiles calculated and reported by the author in his previous paper [see preceding review]. The results agree well with the theory; the pressure center proved to be almost immovable throughout the range of $C_a = 0.3$ to 1.5 as predicted. Also the pressure distribution and the lift coefficient $C_a = 0.6$ agree very well with the theoretical calculation. The calculated profile is compared with test results on a corresponding Clark Y 8% profile.

K. Pilarczyk, USA

5692. Cherkassov, B. A., The influence of the degree of reaction on the load in a turbine stage (in Russian), *Trudi Mosk. Aviats. In-ta* no. 82, 49-58, 1957; *Ref. Zh. Mekh.* no. 2, 1958, Rev. 1769.

The influence of a low degree of reaction in the stage (considered as a means of increasing the working load in the stage) is investigated. Author arrives at the already known conclusions that a decrease in the amount of reaction causes an increase in the velocities λ_{c_1} and λ_{w_1}, which may become supersonic in the first instance in the root sections. This is accompanied by a decrease in the flow temperature T_w^*, owing to retardation of its relative motion, and, consequently, lower blade temperatures. In this manner, a decrease in the reactivity of the stage provides a certain reserve for increasing the gas temperature T_0^*, for a given value of the temperature T_w^*. Applying the very approximate condition of equality of the axial velocities before and behind the rotor, $c_{1a} = c_{2a}$, the author analyzes the influence of the degree of reactivity on the parameters behind the stage. For given values of α_1 and λ_u a reduction in reactivity causes an increase in λ_{2a}, which is associated with an increase in the pressure gradient across the stage. A diagram is presented enabling determination of the stage loading and reactivity on the velocity level in the stage; in particular, to determine the conditions for the appearance of supersonic velocities therein.

V. Kh. Abiants

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

5693. Natalevich, A. S., The critical gas flow condition in a two-dimensional nozzle grid (in Russian), *Trudi Kuybyshevsk. Aviats. In-ta* no. 3, 57-64, 1957; *Ref. Zh. Mekh.* no. 2, 1958, Rev. 1750.

The results are presented of experimental research on nozzle cascades (patterns of the distribution of the equal-pressure lines in the region of the oblique face and least flow section of the cascade duct in the critical condition). From a qualitative analysis of the results and comparison with the flow pattern in the nozzle, the author arrives at the following conclusions: (1) Differing from nozzles in cascades of small pitch with edges of finite thickness, or with a diffuser shape of the oblique face, the critical condition (corresponding to the beginning of changing flow volume and increasing back-pressure) does not coincide with the critical condition of the nozzle; in all cases

$$(\varepsilon_*)_p > \varepsilon_* = \left(\frac{2}{k+1}\right)^{\frac{k}{k-1}}$$

(2) With near-critical conditions in the minimum cross section of the cascade ducts, a mixed form of flow becomes established. With increasing back-pressure the critical flow in the minimum cross section of the ducts gradually transforms into a subsonic flow, starting from the short side of the oblique face; correspondingly, the flow volume changes less than in a symmetrical nozzle. (3) In curvilinear nozzles with an oblique face, as in cascades with thin edges, the critical condition is represented by

$$\varepsilon_* = \left(\frac{2}{k+1}\right)^{\frac{k}{k-1}}$$

but in view of the presence in the throat of the nozzle of a mixed flow, with increasing back-pressure, the flow volume at near-critical states changes less than in the case of a symmetrical nozzle. A. I. Bunimovich

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

5694. Symposium on laboratory testing of hydraulic turbine models in relation to field performance, *Trans. Amer. Soc. Mech. Engrs.* **80**, 7, 1525-1543, Oct. 1958.

5695. Buhning, P. G., On the behavior of axial-flow machines of extremely high specific speed (in German), *VDI-Forschungsheft* **24**, 468, 44 pp., 1958.

According to Cordier's graph for a given machine, once parameters σ (specific speed) and δ (specific diameter) are fixed, there is only one solution in a certain range of the optimal efficiency curve. Modern research has shown that beyond these limits there are different possibilities depending upon the type of construction and losses in the machine. The object of this paper is to obtain graphs containing these new items that are confirmed by experiments. Paper also contains a useful graph showing limits between which it is possible to build axial-flow machines with stator. Author assures that use of the new criterion leads to more efficient and economical machines.

Paper also contains: (a) Discussions of the manner of checking the efficiency of a machine from various points of view; (b) optimum conditions to be selected; (c) criteria for selecting dimensions of the shaft; (d) texts for checking theoretical assumptions and comparison of laboratory results with theory; (e) brief discussion of other theories; and (f) bibliography. Best portion of paper is a magnificent synthesis of modern theory of axial-flow machines, including problems on similitude.

J. L. Sanchez Bribiesca, Mexico

5696. Reich, O., A new procedure to calculate the performance map of reaction turbines (in German), *Maschinenbautechnik* **7**, 11, 586-592, Nov. 1958.

This paper presents a procedure to calculate point by point a map giving the dimensionless flow rate through the turbine as a function of the turbine pressure ratio with the rotational Mach number as a parameter. With this procedure the corresponding efficiencies are also obtained. The procedure applies both to

single- and multistage turbines. It is based on calculation of the velocity triangles in each stage, the corresponding pressures, and temperatures, using loss coefficients as given by Ainley ["Performance of axial flow turbines," *Inst. Mech. Engrs., Proc.* **159,** (1948)]. The repeated calculations are expedited by using a diagram which gives the dimensionless flow rate through a nozzle as a function of the critical Mach number with the losses as a parameter.

No comparison with test data is given.

H. P. Eichenberger, USA

5697. Rudashevskii, G. E., and Nemm, V. A., Investigations of the pressures and deformations in the elements (components) of a variable pitch blade turbine in working conditions (in Russian), Hydroturbine construction, vol. 4, Moscow-Leningrad, Mashgiz, 1957, 127-137; *Ref. Zh. Mekh.* no. 4, 1958, Rev. 4778.

Results are set out for the experimental investigations of the pressure on the blades and on the walls of the chamber and also of the blade deformations of a Tsimlyansk hydroturbine. An analysis of the experimental data led to the following deductions: (1) In the prestarting period the pressure on the blade and in the chamber rapidly increases with increase of the opening of the control apparatus a_0 and attains its maximum magnitude with $a_0 = 30\%$. After starting, the pressure falls and remains constant when normal revolutions are attained. With gathering power the pressure in the chamber increases smoothly, and then, with a_0 between 65 and 70%, it falls abruptly, but later remains approximately constant. (2) The maximum stress ($\sigma = 700$ kg/cm^2) is found in the basal section of the blade in the prestarting period; with increase in the number of revolutions the compression deformation of the tail end of the feather edge of the blade changes to tension and at a normal rate of revolutions the stresses attain 370 kg/cm^2. (3) In the working stage the blade, in a state of vibration, is subject to resonance at a frequency of 20-25 Hertz, close to the frequency of the first independent form of its vibrations, found while taking into account the added mass of the water; here the variable component of the amplitude of deformation constitutes 60% of the static.

A. D. Kovalenko

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

5698. Grishtchuk, S. V., Aerodynamic analysis of the stages of a NZL turbine with twisted blades (in Russian), *Energomashinostroenie* no. 4, 10-12, 1957; *Ref. Zh. Mekh.* no. 2, 1958, Rev. 1771.

The results are discussed of tests made with an experimental, single-stage air turbine, on different variants of blading developed by the NZL, with a low ratio of the mean diameter of the rotor to the blade depth. The influence of the radial clearance on the turbine characteristics is investigated.

N. A. Kolokop'tson

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

5699. Cherkassov, B. A., Some singularities of the three-dimensional flow through a turbine stage (in Russian), *Trudi Mosk. Aviats. In-ta* no. 82, 73-81, 1957; *Ref. Zh. Mekh.* no. 2, 1958, Rev. 1772.

The results are discussed of an experimental investigation on the velocity distribution and degree of reactivity in the interblade ducts of a model, single-stage turbine, with theoretically zero reactivity on the mean diameter.

N. A. Kolokop'tsov

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

5700. Solokhina, E. V., The influence of the size of the axial clearance on the characteristics of gas turbines (in Russian), *Trudi Mosk. Aviats. In-ta* no. 82, 59-72, 1957; *Ref. Zh. Mekh.* no. 2, 1958, Rev. 1777.

An experimental investigation has been made of the influence of the magnitude of the axial gap between the guide ring and the rotor on the efficiency of two model, single-stage gas turbines, profiled according to the laws $c_u r = \text{const}$ and $\alpha_1 = \text{const}$, respectively. It was found that there exists a particular value of this axial clearance at which the efficiency of the turbine is a maximum. This value of the relative axial clearance (ratio of the magnitude of the axial clearance to the length or chord of a guide blade) is, according to the results of the experiments, of the order of 0.25 to 0.32. The use of smaller axial clearances, according to the author, results in abrupt diminution of the stage efficiency, in view of the increased irregularity of the flow in front of the rotor. The use of larger axial clearances, on the other hand, lowers the efficiency to a lesser but still appreciable degree, owing to the increased frictional losses due to the longer path of the gases in the working section of the turbine. The results obtained by the author diverge from other known data on the influence of the axial clearance on the efficiency of a turbine stage.

V.Kh. Abiants

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

5701. Cherkassov, B. A., Calculating the characteristics of multistage gas turbines (in Russian), *Trudi Mosk. Aviats. In-ta* no. 82, 7-29, 1957; *Ref. Zh. Mekh.* no. 2, 1958, Rev. 1774.

Paper is a development of author's previous work, devoted to the methods of calculation of the characteristics of single-stage gas turbines, for the case of the multistage turbine. In the construction of the characteristics, a number of simplifying assumptions are introduced, of which the fundamental is the assumption of coincidence of the parameters of the gas flow at the mean diameter of any stage with the averaged parameters; the velocity coefficients φ and ψ as well as the flow angles α_1 and β_2 can be derived from wind-tunnel tests on two-dimensional or annular cascades. Applying the equation of continuity, energy, and momentum, author determined the parameters of the i-th stage in relation to the referred flow volume at the turbine intake, and the referred peripheral velocity. A method is stated for determining the particular limiting values of the peripheral velocities at which "blocking" of any one blade ring of a multistage gas turbine does not yet take place. The sequence of construction of a turbine characteristic is laid down for the case of subcritical working states, in which gas-dynamical functions and graphs simplifying the calculation are widely used. Calculated characteristics are given for the separate stages of a three-stage turbine for two cases of distribution of the intended heat gradient—with increasing and diminishing gradients in the direction from the first stage to the last. No summation of the characteristics of the individual stages is made, nor any comparison between the resulting calculated data and the experimental results.

V. Kh. Abiants

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

5702. Bykov, N. N., A comparison of the flow capacity of turbine nozzle arrangements with differently-profiled forms (in Russian), *Trudi Mosk. Aviats. In-ta* no. 82, 82-95, 1957; *Ref. Zh. Mekh.* no. 2, 1958, Rev. 1747.

A comparison is made of the flow capacities G of nozzles with profiles following the law $\tan \alpha_1 r^m = \text{const}$, for different values of m but the same characteristics (and consequently, mean flow volumes G_{cp}) on the mean diameter D_{cp}. The method consists essentially of determining the value of the correction term G^0. This latter is obtained in complex integral form, which in certain particular cases of profiling can be considerably simplified and computed analytically (for the relationships: $m = 1$, i.e. $\alpha_1 r = \text{const}$; $m = -1$,

i.e., $c_u r$ = const; $m = 0$, i.e. α_1 = const). In all other cases, recourse must be had to approximate or graphical integration. The results of the calculations are presented in the form of curves of the relationship $G^0 = f(m)$, for different values of α_1, and specified values of $D_{cp}/b = 2.5$, and $\lambda_{cp} = 0.6$. For $m = -1$ ($c_u r$ = const), $G^0 \approx 1$, i.e., the flow volume calculated by the mean diameter coincides sufficiently accurately with the total flow volume through the nozzle arrangement (this conclusion has been given in other sources). With $m = 0$ (α_1 = const), $G^0 = 0.975$ to 0.98, i.e., the volume of flow is 2 to 2½% less than for the case of constant circulation. In general, for $\alpha_1 > 28°$, a development according to α_1 = const will give the minimum flow volume through the nozzle apparatus. Deviations from this law, either toward positive or toward negative values of m may, for deep blades, lead to a perceptible increase in the flow volume.

V. Kh. Abiants
Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

5703. Liepe, F., On the theory of supersonic compressors (in German), *Maschinenbautechnik* **7**, 11, 580–585, Nov. 1958.

Velocity triangles of a supersonic axial flow compressor are investigated assuming no losses except those which occur in a shock. The efficiencies and pressure ratios obtained under these assumptions with a tip speed of about 1300 fps are calculated for various pre-swirl directions. It is assumed that the supersonic velocity at the inlet relative to the rotor is decreased at the outlet to low supersonic velocity. The losses are calculated assuming both a series of oblique shocks and one single normal shock. The curve of dimensionless head versus dimensionless flow rate is also calculated and the head is shown to increase in most cases with increasing flow rate which is in general associated with an unstable characteristic. However, it is pointed out that such a performance may be satisfactory together with a turbine which has a very stable characteristic.

This reviewer finds that this paper stays only on the surface of the theory of supersonic compressors since the most important limiting items such as boundary-layer separation, radial equilibrium, and unsteady flow are not considered in the investigation.

H. P. Eichenberger, USA

5704. Banerjee, D., and Pal, P., Low speed cascade study of a simply generated compressor blade shape, *J. Technol.* **3**, 1, 43–52, June 1958.

5705. Bannister, F. K., Induction ramming of small high-speed air compressor, Instn. Mech. Engrs., Prepr., 17 pp., 1958.

Paper describes experimental and theoretical investigation of effect of inlet pipe on mass flow rate and required driving torque in high-speed single-cylinder air compressor. Experimentally measured effect of inlet pipe on mass flow is increase (up to 18%) or decrease, depending on compressor speed and pipe length. Analysis considers finite-amplitude disturbances but average wave propagation speed is taken everywhere equal to sound speed in undisturbed medium. An experimentally determined steady-flow characteristic is used to relate instantaneous pressure drop and mass flow rate through inlet valve in nonsteady operation, and cylinder pressure is assumed to be uniform at each instant. Analysis indicates fast approach to periodicity from initial quiescent state. Taking third cycle of analysis to represent periodic operation, theory predicts, for experimental conditions of maximum mass flow increment over the "no-pipe" condition, a mass flow increment of 16%, in good agreement with experiment. Effect of inlet pipe may be neutralized by closed-end side pipe branching from it close to the cylinder. J. V. Foa, USA

5706. Mikhail, S., Three-dimensional flow in axial pumps and fans, Instn. Mech. Engrs., Prepr., 16 pp., 1958.

The axial turbomachine flow induced by a thin rotor disk with nonconstant head distribution (nonfree vortex design) is considered by linearizing the partial differential equation. Once the values of a universal function are tabulated, the stream function can be evaluated by an elementary quadrature.

Several fans of the rotor-aft stator type were tested to check the validity of the theoretical analysis and to compare different nonfree vortex with the conventional free vortex design. Measurements of total head, static pressure and flow angles were made at different radii.

It seems that the presented theory gives a reliable and quite accurate basis for designing nonfree vortex machines, specially for lightly loaded blades. Some points of view for the use of nonfree vortex design are included.

N. K. H. Scholz, Germany

5707. Valensi, J., Secondary flows in an axial compressor, Parts I and II(in English), Institut de Mécanique des Fluides, Université d'Aix-Marseille, 61 pp., Nov. 1957.

5708. Rannie, W. D., and Marble, F. E., Unsteady flows in axial turbomachines (in English), C. R. Journées Internationales de Sciences Aéronautiques, Paris, May 27–29, 1957; Paris, ONERA, Part 2, 1–21.

Flow and Flight Test Techniques and Measurements

(See also Revs. 5557, 5631, 5688, 5770, 5771, 5800)

5709. Welsh, W. E., Jr., and Hartnett, J. P., Velocity measurements in the boundary layer and in the main flow between two coaxial disks rotating with equal velocities in air, Proc. Third U. S. Nat. Congr. Appl. Mech., June 1958; Amer. Soc. Mech. Engrs., 1958, 847–855.

Subsonic pressure distributions were obtained for an idealized model of rotating equipment. Disk spacings of 4 to 8 inches and rim Reynolds numbers of 2.4 to 6.2×10^5 were considered. An inner core was found to rotate as a solid body and comparison is made with several single disk theories. The work is an extension of studies by Picha and Eckert. J. R. Baron, USA

5710. Mugler, J. P., Jr., Basic pressure measurements at transonic speeds on a thin 45° sweptback highly tapered wing with systematic spanwise twist variations—wing with quadratic spanwise twist variation, *NASA Memo.* 2-24-59L, 148 pp., Apr. 1959.

Pressure data are presented which were obtained in the Langley 8-ft transonic pressure tunnel. Tests were made at Mach numbers from 0.800 to 1.200 and through an angle-of-attack range of $-4°$ to $20°$. Data were taken at stagnation pressures of both 0.5 and 1.0 atmosphere. The wing has 45° sweepback of the quarter-chord line, taper ratio of 0.15, and aspect ratio 4. A quadratic variation of spanwise twist was built into the wing. The wing was cambered and had a thickened root section.

From author's summary

5711. Prendergast, V., Measurement of two-point correlations of the surface pressure on a circular cylinder, AFOSR TN 58-861 (Univ. Toronto, Inst. Aerophys. TN 23; ASTIA 203 674), 28 pp., July 1958.

Results of an experimental investigation of the two-point correlations of the surface pressure on a circular cylinder are presented. The cylinder was mounted in a wind tunnel at right angles to the flow and contained within it the two microphones which were used as pressure transducers. The curves of correla-

tion coefficient approached a constant asymptote (approximately 0.2), rather than zero at large hole spacing; this is tentatively regarded as a spurious environmental effect. The curves were accordingly adjusted to a zero asymptote. A plot of correlation length v, Reynolds number, computed from the adjusted curves, is presented. From author's summary

Book—5712. Coxon, W. F., Flow measurement and control, New York, Macmillan Company, 1959, x + 312 pp. $11.

Book belongs to series "Physical processes in the chemical industry" and is presumed for use of chemical engineers. The first part is a valuable compendium for everyone occupied with flow measurements. After basic definitions, nine types of fluid meters are classified. A concise theoretical discussion on differential head meters precedes a detailed description of primary elements (orifice plates, nozzles, throats, pitometers) and practical instructions for their installation. Weirs and venturi flumes are treated for measurement in open channels. Typical instruments used in measurements, registering, recording and integrating close the first part. A special part contains principles of automatic control, control of continuous processes, miscellaneous control installation: blast furnace, water supply and treatment, sewerage, pumps, boiler house. Appendix shows revised British standards data on flow measurement, 1957, pitometer measurements in penstocks and discussion on departure from specified conditions. Book is well illustrated with good sketches. Editing is of high standard, only the name of C. Herschel is misspelled.

S. Kolupaila, USA

Book—5713. ASME Power Test Codes: Instrument and apparatus, Part 5, Chapter 4: Flow measurement, New York, American Society of Mechanical Engineers, 1959, 91 pp. $5.

This is the second edition of "Flow measurements," originally issued in 1940, dealing with thin plate orifices, flow nozzles and venturi tubes as the most extensively used types of differential head primary elements. This supplement to the ASME Power Test Codes is not mandatory for acceptance tests. It was prepared by a committee of distinguished experts under H. S. Bean, chairman, therefore the statements are very authoritative. The contents: recommended technique, primary elements, secondary elements, installation, calculation of flow rates, tolerances. Well prepared numerical tables, figures and diagrams are to be particularly commended. Together with a new edition of "Fluid meters" this supplement is of great importance for testing of hydraulic machinery. S. Kolupaila, USA

5714. Persen, L. N., On the theory of the oscillating disk viscometer (in English), 9th Congrès Intern. Mécan. Appl., Univ. Bruxelles, 1957; **7,** 238–248.

Equations of motion are solved by introducing approximations. Author concludes damping effect depends on gas density as well as viscosity. W. H. Sparing, USA

5715. Loving, D. L., and Katzoff, S., The fluorescent-oil film method and other techniques for boundary-layer flow visualization, *NASA Memo.* 3-17-59L, 37 pp., Mar. 1959.

Descriptions and examples are given of several methods recently investigated, particularly the fluorescent-oil film method which appears to be generally simpler and to require less experience and development of technique than previous methods. This method is especially adapted to the large high-powered wind tunnels that require considerable time to reach desired test conditions.

From authors' summary

5716. Bomelburg, H. J., Herzog, J., and Weske, J. R., The electric spark method for quantitative measurements in flowing gases, AFOSR TN 59-273 (Univ. Maryland, Inst. Fluid Dynamics & Appl. Math., TN BN-157; ASTIA AD 212 707), 17 pp. + appendix, Jan. 1959.

The operating principle of the technique and the required instrumentation are described. Characteristics of spark discharges are analyzed theoretically and experimentally. A calibration is established for quantitative evaluation of spark photographs. Examples of application are given for subsonic, transonic, and supersonic flow and for investigations of turbomachines.

From authors' summary

5717. Jones, W. P., Wind-tunnel interference effects on measurements of aerodynamic coefficients for oscillating aerofoils, *Aero. Res. Counc. Lond. Rep. Mem.* 2786, 12 pp., 1958.

The case of a rectangular airfoil describing translational and pitching oscillations in a subsonic wind tunnel of rectangular cross section is analyzed. It is shown that the damping derivatives associated with the pitching degree of freedom are very sensitive to wall effects when the frequency parameter for the motion is small and when the axis of oscillation is not near the quarter chord. A comparison of theory and experiment shows satisfactory agreement for a model with an axis of oscillation near mid-chord.

From author's summary by J. S. Holdhusen, USA

5718. Goethert, B. H., Shock wave reflections in wind tunnels (in English), 9th Congrès Intern. Mécan. Appl., Univ. Bruxelles, 1957; **4,** 407–420.

Author considers properties required in wall of transonic tunnel to give no reflection of shock or expansion wave. Flow fields due to cone-cylinders and other axisymmetric models are considered both theoretically and experimentally. Results show th. reflections cannot be completely avoided with any form of slotted or perforated wall, but wall with greater resistance to inflow than to outflow gives best results. W. A. Mair, England

5719. Libbey, C. E., and Burk, S. M., Jr., A technique utilizing free-flying radio-controlled models to study the incipient- and developed-spin characteristics of airplanes, *NASA Memo.* 2-6-59L, 34 pp., Mar. 1959.

A technique using free-flying unpowered, helicopter-dropped, radio-controlled models has been developed to study the incipient- and developed-spin characteristics of airplanes. In general, the results obtained during the investigation indicated that the technique was feasible for studying the incipient- and developed-spin characteristics of airplanes. The model spin and recovery characteristics obtained by use of this technique were in general agreement with spin-tunnel and full-scale results.

From authors' summary

Thermodynamics

(See also Revs. 5688, 5755, 5756)

Book—5720. Pippard, A. B., The elements of classical thermodynamics, New York, Cambridge University Press, 1957, vii + 165 pp. $2.75 (Paperbound).

Quoting from the author's Preface, this book represents "a short account of the fundamental ideas of thermodynamics, and to keep it short I have deliberately excluded details of experimental methods and multiplicity of illustrative examples." Continuing, from the Preface, "In consequence this is probably not a suitable textbook for the beginner, but I hope the more advanced student will find here a statement of the aims and techniques, which will illuminate any specialized applications he may meet later." It is reviewer's opinion that the author has met his objectives.

After Chapter 1, Introduction, in which the author clearly states the case for study of classical thermodynamics, all of the important concepts and some of the significant applications of thermodynamics are concisely presented. The scope of the book is evident from the Chapter titles: 2, The Zeroth and First Laws of thermodynamics; 3, Reversible changes; 4, The Second Law of thermodynamics; 5, A miscellany of useful ideas (including dimensions, Maxwell's relations and absolute temperature scale): 6, Applications of thermodynamics to simple systems; 7, The thermodynamic inequalities; 8, Phase equilibrium; and 9, Higher-order transitions. Fourteen not-so-simple exercises complete the book.

Although prepared for the advanced student in physics, reviewer believes that engineers and chemists could profit from study of this book. Faculty members might also note how concisely and simply some of the difficult thermodynamic concepts are presented. And in its paperbound edition, cost should be no barrier to students or, even, to faculty.

R. L. Young, USA

5721. Kolodnyi, D. P., Available work in the thermodynamic process (in Russian), *Sb. Nauchno-issled. Rabot. Tashkentsk. Tekstil'n. In.-ta* no. 3, 40–54, 1956; *Ref. Zh. Mekh.* no. 2, 1958, Rev. 1525.

An elementary exposition is given of the cycle of problems associated with the conception of available work. The definition of available work as the sum of the stage work in the system and the work of charging and discharging the circuit is justified. The elementary processes are analyzed in detail; in particular, a new angle is given to the examination of the polytropic process. The particular case is discussed when the available work becomes zero. In all cases attention is directed to the applicability of the relationships obtained in the conditions of an irreversible state change. A relationship is indicated between the available work and the characteristic functions (enthalpy, free enthalpy) of the system. A new form is suggested for the equation of the initial change, whereby the quantity of heat is linked to the enthalpy by the available work. A new definition of enthalpy is suggested, founded on the conception of available work. The superiority of this definition over the definitions current hitherto is demonstrated. This disregards, however, the definition preferred by the present abstractor, of enthalpy as the energy of expansion of the system.

A. A. Gukhman

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

5722. Gasparovic, N., Availability of mechanical work and heat from the exhaust gases of small turbines (in German), *Öst. Ingenieur Z.* **1,** 12, 520–523, Dec. 1958.

5723. Ricard, J., Decrease of reheat and non-reheat cycle efficiency due to bleedings used for preheating purposes (in French), *Chaleur et Industrie* **39,** 391, 27–49, Feb. 1958.

5724. Rasskazov, D. S., and Sheindlin, A. E., Experimental investigations of water and water vapor heat capacity c_p at high pressures and temperatures, *Soviet Phys.-Doklady* **3,** 3, 652–654, Jan. 1959. (Translation of *Doklady Akad. Nauk SSSR (N. S.)* **120,** 4, 771–773, May–June, 1958 by Amer. Inst. Phys., Inc., New York, N. Y.)

5725. McLaughlin, E., Viscosity and self-diffusion in liquids, *Trans. Faraday Soc.* **55,** 1, 29–38, Jan. 1959.

A modified rate-theory approach to the calculation of the transport coefficients of a liquid composed of spherically symmetric molecules has been developed. On the model proposed the existence of holes is a necessary requirement for the transport of mass and momentum to take place. The theory permits calculation of the transport coefficients from one experimental parameter, the molar volume of the liquid, provided the force constants of the molecular interaction derived from the transport properties of the corresponding gases are known. Calculated values of the coefficients of viscosity and self-diffusion for some simple spherical and pseudo-spherically symmetric molecules agree to within approximately 10% of the experimental values.

From author's summary

5726. Dobroklonskii, S. V., Theory of pressure containers fitted with release valves (in Russian), *Trudi Mor. Gidrofiz. In-ta Akad. Nauk SSSR* no. 8, 63–79, 1956; *Ref. Zh. Mekh.* no. 11, 1957, Rev. 12956.

Article deals with the investigation of abnormalities appearing during the measurement of the varying pressures in pressure containers, fitted with a valve affecting both sides of the sensitive element; this valve permits the exclusion or reduction of the influence of slow pressure changes of the medium when recording the mean pressure oscillations. A differential equation is constructed, connecting the velocity of change in pressure drop in the valve and in the sensitive element of the pressure container with the amplitude and velocity of change in pressure of the medium and with the construction parameters of the apparatus—resistance of the valve and the capacity of the chamber. This equation is used for determining the behavior of the apparatus in a number of particular cases of the change of outside pressure: by jumps, by the exponent, in the form of parabolic impulse and when harmonic vibrations of pressure are present. For the last case the amplitude and phase abnormalities are determined and an amplitude-frequency characteristic of the apparatus is constructed. When evolving the equations for the valve resistance, determination was made according to Poiseuille's formula; the conditions were found for the existence of the Poiseuille flow, and the procedure for the experimental determination of the valve resistance was described.

S. M. Zasedatelev

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

5727. Szaniawski, A., Thermodynamics of irreversible phase change processes (in English), *Arch. Mech. Stos.* **10,** 3, 399–416, 1958.

Paper presents an analysis of phase change in a one-component two-phase system using the method of Onsager for small departures from equilibrium. Author derives expressions for mass and volume changes and irreversibility associated with specific external effects on systems. He concludes that mass change from one phase to the other, even in the first approximation near equilibrium, must be accompanied by some irreversibility.

S. J. Kline, USA

5728. Mori, H., Statistical-mechanical theory of transport in fluids, *Phys. Rev. (2)* **112,** 6, 1829–1842, Dec. 1958.

The theory presented is based on the explicit recognition of the fact that there are two relaxation processes in fluids: one is the macroscopic process of attaining spatial uniformity and is represented by the hydrodynamical equations, whereas the other is the microscopic process of attaining internal thermal equilibrium in small mass elements of macroscopic size and determines the transport coefficients. The coupling of the two processes is investigated to obtain the dissipative terms in the transport equations with explicit expressions for the coefficients of viscosity, thermal conductivity, and diffusion, which are valid for liquids as well as for gases.

From author's summary by P. E. Kriezis, Greece

5729. Fenyes, I., Analogy between the mechanical and thermodynamical equations of motion and the Onsager Reciprocity Relation, *Soviet Phys.-JETP* **8,** 4, 725–726 (Letters to the Editor),

Apr. 1959. (Translation of *Zh. Eksp. Teor. Fiz., Akad. Nauk. SSSR* **35**, 1039–1041, May 1958 by Amer. Inst. Phys., Inc., New York, N. Y.)

5730. Bearman, R. J., Statistical mechanical theory of thermal diffusion in binary liquid solutions, *J. Chem. Phys.* **30**, 3, 835–838, Mar. 1959.

The theory of thermal diffusion is developed from statistical mechanics utilizing the concept of the pair space linear relations. These relations have heretofore been used in deriving theories of heat transport and thermal conductivity. The theory of regular solutions is introduced in a thermal diffusion factor derived in terms of statistical mechanical averages over the equilibrium radial distribution functions to yield a relationship among molal volumes, thermal expansion coefficients and compressibility coefficients of the pure components and to the self-diffusion coefficients in the mixture. J. F. Lee, USA

5731. Davydov, B. I., Phenomenological equations of statistical dynamics of an incompressible turbulent liquid, *Soviet Phys.-JETP* **8**, 2, 364–365 (Letters to the Editor), Feb. 1959. (Translation of *Zh. Eksp. Teor. Fiz., Akad. Nauk SSSR* **35**, 527–529, Aug. 1958 by Amer. Inst. Phys., New York, N. Y.)

5732. Agosta, V. D., and Baker, H. D., Determination of nitrogen temperatures by velocity-of-sound measurements, Proc. Third U. S. Nat. Congr. Appl. Mech., June 1958; Amer. Soc. Mech. Engrs., 1958, 709–715.

For systems not in complete thermodynamic equilibrium, a pseudotemperature is defined as that temperature which prevails in the translational states. This assumes: (1) that the translational states are in thermal equilibrium among themselves; and (2) that the energy content of the gas, if all the other energy states were in equilibrium with the translational states, would not differ by a substantial amount from the actual energy content of the gas. It is shown that this defined temperature quantity can be determined from velocity-of-sound measurements in gases. For nitrogen in equilibrium in the range $530\,R \leq T \leq 856\,R$, temperatures calculated from velocity-of-sound measurements agreed to within 1% of those measured by thermocouples.

From authors' summary

Heat and Mass Transfer

(See also Revs. 5400, 5401, 5639, 5640, 5641, 5649, 5650, 5654, 5672, 5724, 5761, 5767, 5768, 5769, 5776, 5831)

5733. Gibson, R. E., A heat conduction problem involving a specified moving boundary, *Quart. Appl. Math.* **16**, 4, 426–430 (Notes), Jan. 1959.

Author considers heat-conduction equation in radially or cylindrically symmetric coordinates when there is heat generation, $A(t)$, throughout the medium and the boundary conditions are $\partial v/\partial r = 0$ at origin, $v[R(t), t] = v_0$; where v is temperature, R a moving boundary. This problem arises when on the surface of existing material there is accretion of new heat-generating material. He solves the problem when (a), $R(t)$ is prescribed as a square root function of time and the heat-generating term has a suitable time variation, and (b) when $R(t)$ is a linear function of time and the heat-generating term is arbitrary. The first problem is solved in terms of confluent hypergeometric functions, the second is reduced to an integral equation and solved by an inverse Laplace transform. G. Horvay, USA

5734. Pucci, C., and Weinstein, A., Heat equation with subharmonic data and generalization (in Italian), *Atti Accad. Naz. Lincei, R. C. Cl. Sci. Fis. Mat. Nat.* (8) **24**, 5, 493–496, May 1958.

Authors first treat the heat equation in an $m+1$ dimensional Euclidean space,

$$u_t = \sum_{i=1}^{m} u_{x_i x_i}, \quad i = 1, \ldots, m. \qquad [*]$$

For subharmonic data specified on the entire hyperplane $t = 0$, it is shown that the solution is everywhere an increasing function of t for $t \geqslant 0$ and is a convex function of $t^{(2-m)/2}$ if $m \neq 2$ and of $\log t$ for $m = 2$. The explicit Poisson-Fourier formula for the solution of [*] and a theorem of F. Riesz on subharmonic functions are used to obtain this result.

Next treated is a generalization of [*], corresponding to heat conduction in a nonhomogeneous medium. With initial data prescribed for u on a bounded region of the hyperplane $t = 0$ and prescribed values for u on the boundary of this region for $0 \leq t \leq 1$, authors derive bounds for u_t, u_{x_i}, $u_{x_i x_j}$ for the solution. Used here is the theorem of M. Picone on the extreme values of solutions of the heat equation.

Authors propose to use these results in forthcoming publications to prove existence and to give applications to numerical calculation of solutions. J. H. Weiner, USA

5735. Rutowski, R. W., Stagnation point heat transfer in a partially ionized gas, Heat Transf. and Fluid Mech. Inst., Univ. Calif., Los Angeles, Calif., June 1959, 110–125.

The purpose of this paper is to compare the measured heat-transfer rate at the stagnation point of a hemisphere mounted in a shock tube, with a calculated value. The calculation is based primarily upon the correlation given by Fay and Riddell for the laminar stagnation point flow. The experimental results tend to agree with the calculations at the lower stagnation temperature (i.e. up to 10,000 K or so) but tend to be somewhat larger than the calculated values in the stagnation temperature range of 12,000 K to 15,000 K. It is conjectured that the difference between the calculations and the measurements is due to the neglect of the effects of ionization on the transport properties. This conjecture tends to be verified if the Busz-Peuckert, Fenkelnburg calculation [*Z. Phys.* **146**, 655–663, 1956] of the thermal conductivity of argon is used.

The significance of the results presented in this paper is, in the opinion of the reviewer, the extension of the validity of the Fay and Riddell heat-transfer correlation. E. E. Covert, USA

5736. Vaglio-Laurin, R., Heat transfer on blunt-nosed bodies in general three-dimensional hypersonic flow, Heat Transf. and Fluid Mech. Inst., Univ. Calif., Los Angeles, Calif., June 1959, 95–109.

Recent results obtained for steady three-dimensional laminar and turbulent boundary layers of a homogeneous gas are extended to include effects of mass transfer and chemical reaction. It is shown that in the presence of negative pressure gradients, of highly cooled surfaces and of moderate Mach numbers of the outer stream, the crossflow and the relevant stresses are negligible even for large transversal pressure gradients. The result is valid also when the gas mixture is ionized and a magnetic field normal to the surface is applied. In the laminar case the system of equations governing similar solution is reduced to that studied recently by Lees in connection with two-dimensional problems; in the turbulent case a new method of analysis is presented for flows involving chemical reaction but no mass addition. Thus simple expressions for evaluating the heat transfer are provided for several laminar and turbulent problems. The essential approximations set forth in the analysis are justified by specific comparisons with experiments and with known exact solutions.

From author's summary by H. Mirels, USA

5737. Carlson, W. O., Heat transfer in laminar separated and wake flow regions, Heat Transf. and Fluid Mech. Inst., Univ. Calif., Los Angeles, Calif., June 1959, 140–155.

Assuming constant pressure in region behind a sudden step on an axisymmetric body, so that the dividing streamline between mixing layer and "dead air" region is a straight line and reattached, the flow is laminar and the Prandtl number is constant, author reduces the boundary-layer equations for compressible flow to two-dimensional incompressible flow equations by the Mangler-Dorodnitsyn transformation. These are solved by the integral method using sixth and fifth degree polynomials for the velocity and enthalpy profiles respectively. An interesting feature of the method is that the integral method is carried out across both "dead air" region and mixing layer, taking into account a reversed flow in the "dead air" region.

Results indicate that in the region just downstream of the step the skin friction is constant and the local Nusselt number is some power of the local Reynolds number, which is erroneously stated to be the first power.

Since no boundary layer is assumed on the forebody and only one experimental set of data is compared with the theory, reviewer feels author claims somewhat more for his theory than is fully justified. Solution at reattachment of dividing streamline is not given, and solution is not for a wake although the experimental data are wake data, so agreement could be coincidental. Several symbols are undefined or not carefully defined and α apparently has two different meanings. R. E. Street, USA

5738. Friedman, A., Generalized heat transfer between solids and gases under nonlinear boundary conditions, *J. Math. Mech.* **8,** 2, 161–183, Mar. 1959.

A generalized boundary-value problem in heat transfer is discussed where, first, the temperature of the gas is a function of the time only and, second, where it depends not only on the time but also on the temperature of the body in a special way—namely, a simple linear expression in the temperature with the coefficient depending on the time where the coefficient possesses certain required and convenient properties. A brief discussion is presented of the case where heat transfer takes place on part of the body. Uniqueness and boundedness theorems on solutions are presented for the homogeneous case followed by a section on nonhomogeneous equations. The method of solution is essentially unique, involving the use of the so-called "maximum principle" and "generalized simple layers." The reviewer believes that the results and methods of solutions are of value to those interested in generalized heat-transfer problems.

E. A. Trabant, USA

5739. Ostroumov, G. A., The temperature of a horizontal wire heated by alternating current, *Soviet Phys.-Tech. Phys.* **3,** 7, 1452–1459, Feb. 1959. (Translation of *Zh. Tekh. Fiz., Akad. Nauk SSSR* **28,** 7, 1575–1584, July 1958 by Amer. Inst. Phys., Inc., New York, N. Y.)

The question of convection cooling of bodies under unsteady-state conditions has not been sufficiently studied. As an initial investigation experiments were made to measure the average temperature along the length of a platinum wire 0.05 mm in diameter and approximately 50 mm long, submerged in various liquids and supplied with alternating current of various frequencies.

From author's summary

5740. Styrikovich, M. A., and Faktorovich, L. E., Effect of tube length on the magnitude of critical heat flow with forced convection of steam-water mixtures, *Soviet Phys.-Doklady* **3,** 3, 518–520, Jan. 1959. (Translation of *Doklady Akad. Nauk SSSR (N. S.)* **120,** 5, 1018–1020, May–June 1958 by Amer. Inst. Phys., Inc., New York, N. Y.)

It has been determined that:

1. With forced convection of a steam-water mixture in a vertical steam-generating tube 3 mm in diameter and for $w_g = 850$ and 3000 kg/m^2 · sec, $p = 26$ atmos and a relative enthalpy of from 0.1–0.2 to 0.8–0.9, the quantity q_{cr} increases by a factor of 1.5–2 when the length of the heated tube decreases from 150 to 35 mm (corresponding to l/d of 50 and 11, respectively). Under 180 atmos, the same values of w_g and a relative enthalpy of from −0.2 to +0.5–0.6, the value of the critical heat flows was seen to increase by a factor of 1.4–1.8.

2. Since the length of the tubes, or the l/d ratio, is, as a rule, considerably higher in industrial installations than in experimental setups, there arises a need for further investigations on the effect of the length and diameter of the heated tube on the value of q_{cr}. From authors' summary

5741. Wadsworth, J., The experimental examination of the local heat transfer on the surface of a sphere when subjected to forced convective cooling, Nat. Res. Counc. Canada, Div. Mech. Engng. Rep. MT-39, 56 pp. + 2 appendixes, Sept. 1958.

The local heat-transfer distribution on the isothermal surface of a sphere had been measured under forced convective cooling conditions over a range of Reynolds number of approximately 20,000 to 240,000, based upon sphere diameter. The results obtained in this range have been compared directly with other work extant in the literature, and the discrepancies noted between the sets of results have been partially explained as a difference of turbulence level in the respective flow facilities. Further effects which could contribute to the discrepancies are the use of different methods of mounting and presenting the spheres to the air flow, and also different blockage ratios incurred by the spheres in their respective flow facilities.

A detailed examination of the flow over the spherical surface has provided a more definite but qualitative explanation of the effect of differences in free-stream turbulence on the heat-transfer distribution. The disturbing effect of the sting, supporting the sphere used in the present work, on the flow close to the sphere and hence on the heat-transfer pattern has also been noted.

From author's summary

5742. Krzywoblocki, M. Z. v., Horiuchi, F. Y., and Voda, J. J., On the similarity rules in diabatic flow, Proc. Third U. S. Nat. Congr. Appl. Mech., June 1958; Amer. Soc. Mech. Engrs., 1958, 771–775.

The diabatic flow is considered to be a flow of an inviscid, non-heat-conducting fluid with heat addition by means of sources, i.e., injection of heat. The governing fundamental equations for such a flow are: the first law of thermodynamics, Euler's equation of motion and a pressure-density-entropy relation. In the first part the authors generalize the Prandtl-Glauert formula to diabatic, rotational flow; in the second part they derive a generalized similarity formula in the hodograph plane.

From authors' summary

5743. Hill, J. A. F., Integral methods for laminar forced convection calculations—an evaluation of two approaches (in English), 9th Congrès Intern. Mécan. Appl., Univ. Bruxelles, 1957; **4,** 108–120.

Author summarizes methods used by Crocco and Cohen [50 Jahre Grenzschichtforschung, H. Görtler & W. Tollmien, eds., Vieweg und Sohn, Braunschweig, 1955] and Rott and Crabtree [AMR **6** (1953), Rev. 1679] for calculating heat transfer through the incompressible laminar boundary layer over forward parts of an isothermal body in a uniform stream, and compares results for wedge flows with an exact solution due to Frössling [Lunds Universitets Arsskrift N. F. Avd 2, 36, 1940]. Rott and Crabtree's results give good agreement and are recommended; Crocco and Cohen's heat-transfer rates are somewhat too high.

B. R. Morton, England

5744. Goldsworthy, F. A., The structure of a contact region with application to the reflexion of a shock from a heat-conducting wall, *J. Fluid Mech.* **5,** 1, 164–176, Jan. 1959.

Paper considers structure of an interface propagating in one-half-plane created by sudden heating of gas in the other half-plane. Main attention is devoted to constant velocity interface with thermal conductivity constant, linear and quadratic function of temperature. Temperature profiles and velocity and pressure perturbation are computed for two ratios of temperature across interface. Similar analysis is applied to determine attenuation of the normal reflection of a shock from a plane, heat-conducting wall.

P. A. Libby, USA

5745. Borishanskii, V. M., and Kutateladze, S. S., Heat transfer and hydraulic resistance during flow of liquid metals in circular tubes, *Soviet Phys.-J. Tech. Phys.* **3,** 4, 781–791, Dec. 1958. (Translation of *Zh. Tekh. Fiz., Akad. Nauk SSSR* **28,** 4, 836–847, Apr. 1958 by Amer. Inst. Phys., New York, N. Y.)

Experimental data are presented for bismuth, bismuth-lead eutectic and sodium flowing in circular tubes. Isothermal and nonisothermal experiments were undertaken over a range of Peclet number of 100 to 11,000, Prandtl number of 0.005 to 0.035 and tube diameters 5 to 35 mm with an L/D ratio ranging from 15 to 100. All runs were for Reynolds number greater than 10,000. Heat-transfer results are correlated by Martinelli-Lyon-type equations, $Nu = 4.3 + 0.0021\ Pe$ (for L/D greater than 30, Pe greater than 300) and $Nu = 0.7\ (Pe)^{\frac{1}{2}}$ (for L/D greater than 30, Pe between 50 and 100). Friction coefficients for isothermal and nonisothermal runs followed the usual square power law. In a few of the runs, adding magnesium to lead-bismuth eutectic did not result in any appreciable change in its heat-transfer characteristics. Detailed description of the experimental apparatus is presented.

R. G. Nevins, USA

5746. Kutateladze, S. S., Heat transfer during flow of liquid metals in tubes and on plane plates, *Soviet Phys.-J. Tech. Phys.* **3,** 4, 792–798, Dec. 1958. (Translation of *Zh. Tekh. Fiz., Akad. Nauk SSSR* **28,** 4, 848–854, Apr. 1958 by Amer. Inst. Phys., New York, N. Y.)

The relative importance of eddy and molecular diffusivities of heat in turbulent flow of liquid metals in tubes is discussed. The equation for Nusselt number, derived originally by Lyon, is first integrated for the limiting case of zero Prandtl number, using the seventh power law for the velocity distribution to give a value of 6.8. It is pointed out that the ratio of eddy diffusivities of heat and momentum, for liquid metals, is less than 1 and depends on Prandtl number and distance from the pipe wall. Lyon's equation is also integrated for various values of Reynolds number and different Prandtl numbers. An average value of the ratio of eddy diffusivities was used and the results are approximated by an empirical relation. The variation of physical properties of the liquid metal with temperature is shown to have a slight effect on the film coefficient.

The integral energy equation for flow of liquid metals over a flat plate is integrated using a fourth-degree polynomial for the velocity and temperature profiles to give the ratio of the thickness of hydrodynamic and thermal boundary layers as a function of Prandtl number. The dependence of Nusselt number on Prandtl number and the square of Grashof's number during free convection in liquid metals is also discussed.

R. G. Nevins, USA

5747. Ostroumov, G. A., and Tetiuev, V. A., On the question of the theory of free thermal convection in cylindrical cavities, *Soviet Phys.-Tech. Phys.* **3,** 6, 1173–1174, Feb. 1959. (Translation of *Zh. Tekh. Fiz., Akad. Nauk SSSR* **28,** 6, 1261–1262, June 1958 by Amer. Inst. Phys., Inc., New York, N.Y.)

The following points have been established experimentally:

1. In the theoretically thresholdless case of an inclined tube heated at the lower end, clearly marked threshold effects have been discovered.

2. In laminar flow occupying the entire cross section of the tube (in the absence of foci of turbulence) local disturbances of the flow spontaneously arise and die out; these are pulsations, producing zigzag tracks in photographs.

3. Therefore, the radial (and azimuthal) component of the thermal flux is due not only to molecular but also to convective heat transport. Indications of an enhanced thermal conductivity of the laminar flow have also been noted in earlier work.

4. The theory constructed for an accurately vertical tube, without taking radial convection into account, applies very well to tubes that are inclined to a moderate degree. For large inclinations the characteristic Rayleigh number is increased.

From authors' summary

5748. Foote, J. R., An asympototic method for free convection past a vertical plate (in English), *ZAMP* **9,** 1, 64–67, Jan. 1958.

The problem of free convection from a vertical nonisothermal flat plate is, by means of asymptotic expansions, reduced to the finding of a series of functions which satisfy linear ordinary differential equations with constant coefficients. Solutions for the first three functions of the series are indicated in terms of a parameter which can be found from an eighth-degree biquadratic equation. The method used is an extension of that applied by Fettis [Proc. Fourth Midwest Conf. Fluid Mech., 1956; AMR **10** (1957), Rev. 807] to the isothermal case.

The problem considered has been solved by Sparrow and Gregg [*Trans. ASME,* **80,** 1958; AMR **11** (1958), Rev. 2331] by integration of the nonlinear equations on a high-speed computing machine.

S. Ostrach, USA

5749. Tewfik, O. K., and Giedt, W. H., Local heat transfer, recovery factor, pressure distribution around a circular cylinder normal to a rarefied supersonic air stream, Heat Transf. and Fluid Mech. Inst., Univ. Calif., Los Angeles, Calif., June 1959, 15–26.

Measurements were made in the range $1.3 < M < 5.9$, $37 < Re <$ to 100, and for cylinder temperatures of 90K and 210K. Empirical equations for local heat transfer and pressure distribution are found. Effects of cylinder wall temperature level and gradient on the heat-transfer and pressure distributions are discussed.

From authors' summary by S. H. Maslen, USA

5750. Scala, S. M., Hypersonic stagnation point heat transfer to surfaces having finite catalytic efficiency, Proc. Third U. S. Nat. Congr. Appl. Mech., June 1958; Amer. Soc. Mech. Engrs., 1958, 799–806.

The use of "non-catalytic" coatings has been suggested as a means of reducing the heat absorbed by a hypersonic vehicle by minimizing the catalytic recombination of atomic species. The theoretical merits of such coatings are investigated by solving the governing system of nonlinear differential equations subject to the appropriate conditions of velocity, temperature, pressure and molar concentrations of reacting gaseous species, at the stagnation point of the body. The effects of homogeneous and heterogeneous atom recombination are included and the results obtained yield the unique relationship between the catalytic efficiency of a surface and the heat transfer from the flowing dissociated gas which envelopes the vehicle.

From author's summary

5751. Takao, K., and Fujimoto, T., Heat transfer in the rarefied gases, *Mem. Fac. Engng., Univ. Nagoya* **9,** 2, 379–389, Nov. 1957.

Authors compute steady-state temperature distribution due to heat conduction between two parallel plates for temperature differences small compared to the ambient. The distribution function for molecules impinging on a wall is different from that of the

molecules reflecting from the wall. Sufficiently far from the wall, the distribution function reduces to that derived by Grad [*Comm. Pure Appl. Math.* **2**, p. 331, 1949].

The result obtained, which reduces to known limiting cases of free molecule flow and continuum flow, should be valid throughout the entire slip-flow regime. The authors state that certain difficult definite integrals which occur in the analysis can be easily evaluated by experiment. H. A. Stine, USA

5752. Davies, D. R., and Bourne, D. E., Heat and mass transfer in a turbulent boundary layer (in English), 9th Congrès Intern. Mécan. Appl., Univ. Bruxelles, 1957; **4**, 50–59.

The heat transfer from a flat plate with an incompressible boundary layer is investigated. The data of Elias [ZAMM **10**, no. 1, 1930], which apparently is still the only available set of velocity and temperature distributions, are utilized. By approximating the velocity distribution and boundary-layer thickness by power functions an expression for the eddy viscosity is obtained from the momentum equation. In the inner portion of the boundary layer the eddy viscosity can also be approximated by a power function. Assuming that the eddy conductivity is given by this power function and using von Mises' transformation gives a linear partial differential equation for the temperature distribution. The solution agrees quite well with experiment. The paper is part of a series and a subsequent paper [AMR **12** (1959), Rev. 887] is also available.

Reviewer believes that the analysis involves assumptions which restrict its validity to moderate Prandtl (or Schmidt) numbers. Also there is a typographical error in Eq. [3] where X^2 would be X^q. W. Squire, USA

5753. Hayday, A. A., Mass transfer cooling in a steady laminar boundary layer near the stagnation point, Heat Transf. and Fluid Mech. Inst., Univ. Calif., Los Angeles, Calif., June 1959, 156–170.

Plane and rotationally symmetric flow regions near a stagnation point are considered. Hydrogen is injected uniformly through the porous surface, and velocity, concentration, and temperature profiles are calculated in the laminar boundary layer near the stagnation point, using a numerical method. Numerical results show the effect of various amounts of hydrogen on the heat-transfer, skin-friction, and concentration and temperature profiles, with various mainstream temperatures.

Results are useful, but the paper is not well presented and some of the notation, e.g. Euler number, is not defined.

J. F. Davidson, England

5754. Scala, S. M., Vaporization of a refractory oxide during hypersonic flight, Heat Transf. and Fluid Mech. Inst., Univ. Calif., Los Angeles, Calif., June 1959, 181–192.

During flight through a hypersonic environment, the heat transfer to a vaporizing surface depends critically upon the aerothermochemical processes which occur in the boundary layer. In this study of heat and mass transfer effects, the pertinent conservation equations are presented and are employed in an analysis of the processes of diffusion, convection and thermal exchange during the vaporization of a refractory material which reaches extremely high surface temperatures, such that re-radiation must be considered at the surface. ..... The effects of nonequilibrium vaporization into a hypersonic laminar boundary layer are treated.

From author's summary by T. R. Goodman, USA

5755. Mansfield, W. W., The influence of monolayers on evaporation from water storages, Part I; The potential performances of monolayers of cetyl alcohol, *Austral. J. Appl. Sci.* **9**, 3, 245–254, Sept. 1958.

It is estimated that permanent and complete application of a molecular film of cetyl alcohol to the surface of a water storage should reduce annual evaporative losses by 50% or more. The effects of varying atmospheric conditions on the ability of such a film to reduce evaporation are outlined.

From author's summary

5756. Mansfield, W. W., The influence of monolayers on evaporation from water storages, Part II; Evaporation and seepage from water storages, *Austral. J. Appl. Sci.* **10**, 1, 65–72, Mar. 1959.

The influence of depth of water upon the annual evaporative cycle of a water storage is estimated. The relations between storage evaporation and losses from an evaporimeter are outlined. It is shown that seepage losses from a storage may be determined from variations in its total chloride ion content.

From author's summary

5757. Free, K. W., The production of solar salt, *Trans. Instn. Chem. Engrs.* **36**, 2, 115–121, Apr. 1958.

Author considers the operation of pond systems for the production of salt by solar energy from sea water. Using reported behavior of sea water being concentrated and solar evaporation data, an analysis of single-, two- and three-pond system determines annual yield of saturated brine for a 12-inch pond depth. Considering the behavior of the crystallizing section together with deep storage of the brine indicates that a four-year cycle of operation is most attractive management scheme.

W. E. Ibele, USA

5758. Laboontzov, D. A., Heat transfer in film condensation of pure vapours on vertical surfaces and horizontal pipes (in Russian), *Teploenergetika* no. 7, 72–80, 1957.

Theoretical equations previously derived by the author are compared with experimental data for laminar and turbulent film condensation. In the laminar region the heat-transfer coefficient computed from Nusselt's equation is multiplied by correction factors which take into account the effects of liquid inertia, convective transport, wave motion and temperature dependence of the physical parameters. Good agreement is reported for both laminar and turbulent region. N. Zuber, USA

5759. Macioce, E., Theoretical study of a fog-dispersing system on landing strips (in Italian), *Riv. Aero.* **34**, 11, 1657–1669, Nov. 1958.

Author considers energy requirements associated with a cycle in which outside humid air is first compressed, then dried, and finally expanded and released at atmospheric conditions. It is concluded that, in absence of lateral wind, 30,400 hp are needed to disperse the fog from a volume of 10^6 m^3 in a time period of 1000 seconds. With a wind blowing in a lateral direction to the landing strip the power requirements are considerably higher.

N. Zuber, USA

5760. McKeon, J. T., and Eschenbrenner, G. P., Thermal analysis and design of intermediate heads in pressure vessels, ASME-Petroleum-Mechanical Engng. Conf., Denver, Colo., Sept. 1958. Pap. 58-PET-32, 32 pp.

Steady-state and transient temperature distributions are discussed for a three-way junction between the skins of an external cylindrical pressure vessel and an internal pressure head which divides the main vessel into two compartments that may be subjected to different pressures. The thermal stresses based on the heat-transfer problem along the skins together with stresses resulting from the pressure loading furnish a basis for the design of such containers. The steady-state heat-transfer problem is analyzed by an approximate theory. These results are checked by an electrical analog network which is then used to handle the transient case. The discussion is concluded by a numerical examples. F. T. Geyling, USA

Combustion

(See also Rev. 5791)

Book—5761. Thring, M. W., Fabri, J., Lefebvre, A. H., and Lutz, O., edited by, Combustion and propulsion: noise, shock tube, magnetic effects, instability and mixing (Third AGARD colloquium, Palermo, Sicily, Mar. 1958); New York, Pergamon Press, 1958, xii + 614 pp. $20.

The Third AGARD Colloquium is a compilation of 21 papers on power-plant requirements, interaction of combustion systems with engine components, aircraft noise, combustion, aerophysical chemistry, flame stabilization and jet mixing.

Most papers are cursory and limited reviews. The best articles are in the field of aerophysical chemistry. Lees' paper on convective heat transfer with mass addition and chemical reactions is excellent and will undoubtedly become a classic in its field.

A stimulating article by Spalding introduces the concept of seven useful half-truths in combustion. These half-truths developed from complicated theories could become "nearly true laws" which engineers could readily comprehend and find useful in development work.

The survey on air-breathing power plants, noise and composite propellant problems may be useful to some.

I. Glassman, USA

5762. Zeldovich, Y. B., and Barenblatt, G. I., Theory of flame propagation, *Combustion and Flame* **3,** 1, 61–74, Mar. 1959.

The approaches of several others to the solution of the problem of the propogation of a flat flame are critically commented on. Authors give their method of solution and consider the effects of the ratio of heat transfer coefficient to diffusion coefficient, heat losses, and chain reactions. They conclude that for the uni-dimensional problem the flame is always stable.

J. H. Grover, USA

5763. Jayaraman, V., Hulse, C., and Thring, M. W., Model investigations into the factors affecting the mixing of gas and air in coke oven flues, *Combustion and Flame* **3,** 1, 97–104, Mar. 1959.

The length of the heating flame in a coke oven flue is governed only by the mixing of the gas and the air, but the factors that govern such mixing are not clear. This model work is an attempt to establish these for the case of rich (coke oven) gas firing. It has been found that a wide range of flame lengths can be obtained for the same flow rates by employing burners and airports of different cross-sectional area. A scale theory is put forward to render the model results applicable to actual systems. The theory has been roughly confirmed for a particular case by carrying out full-scale trials in an operating coke oven flue. Work on further confirmation is in hand at Sheffield.

From authors' summary

5764. Jensen, W. P., Raymond, P. M., and Tobey, A. C., Modeling studies of sub-atmospheric combustors, WADC TR 58-620 (ASTIA AD 208 857), 42 pp., Dec. 1958.

An experimental study has been conducted to determine the model laws which govern scale-up of high-output combustion systems. Of three systems chosen, major effort was devoted to study of a geometrically similar family of ramjet-type burners, of 1.6-, 3-, 4-, and 6-inch diameter.

Two other systems also studied from the modeling point of view were diffusion flames of propane jets and non-burning heated-air jets mixing with ambient air, and the variables in each case were ambient pressure, jet diameter and jet velocity. Results of these studies show that the jet flame can be fairly well characterized in terms of the Reynolds number, and the parameter $U/p^n - 1L$, but it is not possible to state conclusively whether this result is due only to chemical effects or to a combination of chemical and buoyancy effects. The heated-air jet is adequately described by the Reynolds and Froude numbers.

From authors' summary

5765. Elias, I., Acoustical resonances produced by combustion of a fuel-air mixture in a rectangular duct, *J. Acoust. Soc. Amer.* **31,** 3, 296–304, Mar. 1959.

An experimental program was conducted with a 2½ × 10-in. model ramjet combustor directed toward understanding the mechanisms which maintain high-frequency combustion pressure oscillations (commonly referred to as "screech") in the air-breathing jet engine. Results show that pressure oscillations characteristic of transverse acoustic modes occur as fuel-air mixtures approach stoichiometric values. The particular mode excited is related to orientation of the flame fronts in the duct, which in turn are functions of the particular flame holder geometry. It is shown that heat release associated with the flame fronts occurs in high-impedance zones for the modes excited. High-speed motion pictures of the combustion zone during screech show that the flame fronts are serrated, the number of serrations being proportional to screech frequency. The serrations are interpreted to be related to vortex shedding from the flame holder lips. High-amplitude oscillations corresponding to the fundamental longitudinal mode occurred when conditions of intense screech were achieved. This mode transference is attributed to increased heat addition in the forward portion of the duct, a position favorable for driving longitudinal modes. Preliminary results show that high-turbulence levels produce screech at lower values of fuel-air mixture.

From author's summary

5766. Ribaud, G., and Manson, N., Application of constants and thermodynamic properties of gaseous mixtures at high temperatures (flames, motors, and combustors) (in French), *Publ. Sci. Tech. Min. Air, France,* no. 341, 194 pp., 1958.

Graphical methods of calculating temperature and composition of chemically reacting gases are presented using the previously reported thermodynamic data [see *Publ. Sci. Tech. Min. Air, France,* nos. 266 & 294]. Applications are given for the calculation of: (a) combustion temperature at constant pressure in furnaces, gas turbines and solid and liquid rockets: (b) steady flow of gases in nozzles; (c) performance of gas turbine engines (including afterburning), ramjets and rockets; (d) constant-volume combustion; (e) reciprocating engine cycles with internal combustion; (f) thermodynamic properties of shock waves and detonations.

The method, applicable to gases containing carbon, hydrogen, oxygen and nitrogen, is similar to others reported in the literature.

M. Gerstein, USA

5767. Adrianov, V. N., and Shroin, S. N., Investigation into heat exchange in the gas combustion chamber (in Russian), *Teploenergetika* no. 4, 62–67, Apr. 1959.

A system of determining invariants was obtained on the basis of analysis of the equations describing the operating processes which take place in the combustion chambers. By means of an experimental investigation carried out on a model, the effect produced by hydrodynamic characteristics of the flow upon the process of heat exchange in a gas combustion chamber has been examined.

From authors' summary

5768. Abrukov, S. A., A method for determining the temperature field of the flame of carbon monoxide in air (in Russian), *Uch. Zap. Kazansk. Gos. In-ta* **115,** 12, 3–23, 1955; *Ref. Zh. Mekh.* no. 2, 1958, Rev. 1645.

A method is suggested for determining the temperature field of an axially symmetrical flame of a Bunsen burner, burning inside a special square casing intended to eliminate the influence of extraneous, lateral convective air currents. A Toepler apparatus

was used, a filament of 0.04 mm being placed in the principal focus of the observation tube, the collimator slit being 0.035 mm wide. With such a combination of the dimensions of the slit and the filament, the entire image of the flame is covered with interference bands. From a single photograph of the interference pattern, using the method of approximate solution of the integral equations [H. Schardin, *Forschungsheft VDI* p. 367, 1934], the field of the refractive index can be determined. Utilizing the similarity relationship of the temperature field and the concentration field of CO_2 and air in a flame, author next calculates the temperature field. Numerical examples follow. The author assumes that the accuracy of determination of the refractive index from the interference lines in a Toepler apparatus is not less than the accuracy of such a determination by interferometer. A special experiment has shown that for one and the same flame the temperature values found from 7 different photographs differ from each other by not more than 6% for the inner cone, and not more than 3% for the outer cone. The maximum temperature in the flame of a stoichiometric mixture equals 1870 ± 56°; the theoretically calculated temperature is 2030°. The divergence of these values can be explained by radiation into the surrounding, colder medium.

L. S. Dmitriev

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

5769. Agababov, S. G., Radiative power of furnace slags (in Russian), *Teploenergetika* no. 8, 56–60, Apr. 1958.

Deviations of the radiation emitted by a hot solid or fluid from black-body radiation are determined by the coefficient of blackness. This coefficient is measured for a number of slags and glasses in the solid and liquid state. Measurements are made by pyrometric methods. They are, if necessary, supplemented by measurements of the temperature of the radiating body by means of thermocouples. For most of the materials the coefficient of blackness is found to be approximately 0.95 at room temperature and decreases below 0.7 at 1500C.

Information on experimental particulars is not sufficient for assessing the accuracy of the results obtained; it is, presumably, sufficient for practical purposes.

R. Eisenschitz, England

5770. Allen, H., Jr., and Fletcher, E. A., Combustion of various highly reactive fuels in a 3.84- by 10-inch Mach 2 wind tunnel, *NASA Memo.* 1-15-59E, 28 pp., Apr. 1959.

Attempts were made to burn a number of highly reactive fuels below the top wall of a Mach 2 wind tunnel. Of the fuels investigated the following were successfully burned and gave associated pressure rises: aluminum borohydride, pentaborane, mixtures containing up to 41 percent JP-4 fuel in aluminum borohydride, and JP-4 fuel piloted by an aluminum borohydride flame. When water was injected along with trimethyl aluminum and diethyl aluminum hydride, the combustion of these two fuels could also be accomplished. Studies probing the combustion region with water injections indicated that the flow downstream of the flame front is subsonic and recirculating.

From authors' summary

5771. Dorsch, R. G., Serafini, J. S., Fletcher, E. A., and Pinkel, I. I., Experimental investigation of aerodynamic effects of external combustion in airstream below two-dimensional supersonic wing at Mach 2.5 and 3.0, *NASA Memo.* 1-11-59E, 19 pp., Mar. 1959.

Pressure distributions associated with stable combustion of aluminum borohydride in the airstream adjacent to the lower surface of a 13-inch chord, two-dimensional, blunt-base wing were determined experimentally. Measurements were made with the wing at 2° angle of attack in a 1- by 1-ft tunnel at Mach 2.47 and 2.96. Static-pressure increases along the lower surface and base caused by the combustion are presented along with the resultant lift increases. The lift-drag ratio of the wing was nearly doubled by the addition of heat. The experimental values of lift during heat addition agree with those predicted by analytical calculations.

From authors' summary

5772. Barrere, M., The combustion of fuel drops and monopropellant drops, Parts I and II (in French), *Flamme et Thermique* **10,** 118, 13–38, July 1958; **10,** 119, 22–34, Aug. 1958.

A general survey of combustion problems of liquid fuel drops and monopropellant drops based on the literature of the last five years (by Godsave, Kumagai and Isoda, Goldsmith and Perkins, Kobayasi, Spalding, Rex, Fuhs and Penner, von Karman and others). The concepts and principles of aerothermodynamics and aerothermochemistry are explained. Paper treats the concepts of mixture ratio, diffusion flames, and pre-mixed flames. Experimental methods are discussed in which (1) the droplet is stationary and the gas stream is in motion, and (2) the gas is stationary and the droplet is in motion. Author describes and illustrates the experimental equipment used at ONERA for burning the droplets and observing the diminishment of diameter, for measuring the ignition delay and the zone of separation between the flame and the liquid drop surface. Curves are given of typical test results. Author discusses the difference in flame configuration between fuel drops and monopropellant drops. Successive photographs of burning droplets are shown, and also the history of diminishing diameters derived from them. Effect of oxygen concentration on combustion is discussed and charted. Effect of temperature and of pressure of the combustion air is described. The basic equations and functions of combustion theory are listed, with derivations. It is emphasized that the findings valid for single drops are not fully applicable to the combustion of a multitude of drops in furnaces, and that many problems yet await solution.

K. J. DeJuhasz, Germany

5773. Lvov, D. P., The similarity of the velocity head fields of a cold and a burning, powdered coal spray (in Russian), Vses. N.-i. In-ta Metallurg. Teplotekhn. Byul. Nauchno-tekhn. Inform. no. 2, 43–46, 1957; *Ref. Zh. Mekh.* no. 2, 1958, Rev. 1762.

An investigation of the velocity head fields in different cross sections of a cold and a burning powdered coal spray, for a number of different burner types. For each burner, the experimental spots for the cold and the hot spray lie on a single curve.

L. S. Dmitriev

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

Prime Movers and Propulsion Devices

(See Revs. 5700, 5701, 5722, 5786, 5788, 5789, 5791, 5793)

Magneto-fluid-dynamics

(See also Rev. 5735)

5774. Donaldson, C. DuP., The magnetohydrodynamics of a layer of fluid having a free surface, Heat Transf. and Fluid Mech. Inst., Univ. Calif., Los Angeles, Calif., June 1959, 55–67.

The analysis treats an essentially one-dimensional open channel flow of an electrically conductive liquid in the presence of a vertical external magnetic field. The electric current crosses the channel horizontally perpendicular to the flow direction and it returns through a special conductor placed under the channel. The

imposed external magnetic field is vertical in direction and its intensity may vary slowly along the flow direction. In addition there will be an induced magnetic field in the flow direction attaining maximum intensity between the liquid and the shorting plate. In the analysis, viscosity is neglected but electrical conductivity is assumed to be finite.

The first finding is that the hydrostatic pressure at the bottom of the channel may be cancelled out if the magnetic field is of sufficient strength. The unsteady small perturbation (linearized) analysis shows that the gravity waves now suffer a magnetic damping. When the steady flow is presented in a non-dimensional form (by using analogous compressible flow parameters such as Mach number) the findings are similar to the treatment of the one-dimensional compressible flow case given by Resler and Sears [*J. Aero. Sci.* **25**, 4, 235–245, 1958; AMR **12** (1959), Rev. 1032].

L. S. G. Kovasznay, USA

5775. Chang, C. C., and Lundgren, T. S., The flow of an electrically conducting fluid through a duct with transverse magnetic field, Heat Transf. and Fluid Mech. Inst., Univ. Calif., Los Angeles, Calif., June 1959, 41–54.

This paper extends earlier work by Hartman and by Shercliff [AMR **12** (1959), Rev. 476] on the steady flow of an electrically-conducting fluid through a straight duct in a transverse uniform magnetic field. The flow equations are derived with emphasis placed on boundary conditions on velocity at the rigid walls of the duct and on the pertinent components of the electric field intensity and magnetic flux density at electrical interfaces and at infinity. If the walls of the duct have finite conductivity, the solution of the problem does not parallel the solution of an ordinary boundary-value problem except in special cases: Perfectly insulating or conducting walls, thin duct walls, and so forth. The flow through a rectangular duct with walls parallel to the external field displaced to infinity and the other walls of arbitrary wall conductivity is solved exactly. The flow through a finite rectangular duct with perfectly conducting walls is also solved exactly; and a different exact solution in series form is given for the perfectly isolating walls, complementing the different solutions obtained earlier by Shercliff. These solutions reveal that when the wall conductivity is increased, the pressure gradient must be increased to maintain the same mass flow. T. J. Higgins, USA

5776. Williams, J. C., III, The decaying plasma as a method of heating a supersonic gas stream, Heat Transf. and Fluid Mech. Inst., Univ. Calif., Los Angeles, Calif., June 1959, 222–235.

Paper investigates dissociative recombination as a mechanism of heat addition in supersonic flow. Specifically, the decay of a slightly ionized nitrogen gas in one-dimensional flow is analyzed. One-dimensional conservation equations are presented. An approximate solution is given by assuming that the species continuity equations are uncoupled from the other conservation equations. This mathematical simplification makes the solution more convenient, but the results nearly physically meaningless. An interesting result is that a very long decay time is indicated. Discussion of the general characteristics of supersonic heat addition is naive and at times incorrect. The entropy, being a state point function, is not dependent upon the mechanism of heat addition. The conclusion that the most efficient method of heating is to add heat at a constant low supersonic Mach number implies either a two-dimensional channel (not discussed nor analyzed) or very small heat addition. R. A. Gross, USA

5777. Globe, S., The suppression of turbulence in pipe flow of mercury by an axial magnetic field, Heat Transf. and Fluid Mech. Inst., Univ. Calif., Los Angeles, Calif., June 1959, 68–79.

An experimental investigation has been made of the effect of an axial magnetic field on transition from laminar to turbulent flow and on the turbulent friction factor for pipe flow of mercury. Magnetic flux densities up to 5700 gauss were obtained with a water-cooled solenoid. Pipes of glass and aluminum of approximately 0.1-in. and 0.2-in. diameter were used. The maximum Hartmann number (product of field flux density, hydraulic radius, and the square root of the electrical conductivity divided by the kinematic viscosity) was about 20. Measurements were made of the pressure gradient and velocity of flow. The transition Reynolds number was determined from the curve of friction factor against Reynolds number.

The results show an increasing value of minimum transition Reynolds number with Hartmann number: at the highest value of the Hartmann number the minimum transition Reynolds number was increased to about 1.8 times the value of zero magnetic field. The results can be correlated with an empirical modification of Stuart's stability theory for plane Poiseuille flow.

The magnetic field also brought about a decrease in the turbulent friction factor and corresponding shear force at the wall. For Reynolds numbers just above transition the decrease in friction factor was about 30%. As the Reynolds number increased, the magnetic field brought about less of a decrease in the turbulent friction factor. For a Hartmann number of 20, there was no effect of the magnetic field above a Reynolds number of about 11,000.

From author's summary by W. F. Davis, USA

5778. Palmer, J. L., Laminar flow in magnetically focused cylindrical electron beams, AFOSR TN 58-990 (Univ. of California, Div. Elec. Engng.; ASTIA AD 205 908), 25 pp., Nov. 1958.

The behavior of a cylindrical electron beam in a magnetic field is discussed in terms of a laminar-flow model. By numerical integration of the equations of motion the maximum and minimum radii of excursion and the wavelength of the undulations for each electron are presented in graphical form for various boundary conditions on the electron beam. By the proper selection of the boundary conditions, e.g., magnetic field strength at the cathode, the graphs are utilized to describe Brillouin flow, space-charge-balanced flow, immersed flow, confined flow, and, in fact, any electron flow which satisfies the laminar flow criterion. The perturbations introduced by improper injection conditions for any of the flows mentioned can be read directly from the graphs. A study of the wavelength and the amplitude of such perturbations as a function of radial position in the beam determines if a given type of flow with given injection conditions satisfies the laminar flow criterion. The sensitivity of the various types of electron flow to misadjustments of the boundary conditions is clearly revealed by the graphs, e.g., the amplitude of the undulations in Brillouin flow is very sensitive to the adjustment of the magnetic field strength, whereas for immersed flow a similar deviation in magnetic field strength has very little effect on the amplitude of the undulations.

From author's summary

5779. Bush, W. B., Magnetohydrodynamic-hypersonic flow past a blunt body, *J. Aero/Space Sci.* **25**, 11, 685–690, 728, Nov. 1958.

Flow field near the stagnation point of an axisymmetric blunt body in hypersonic flow is analyzed for a spherical detached shock. A magnetic field is applied to the fluid in the shock layer which is assumed to be incompressible, inviscid, and of constant electrical conductivity. A family of solutions is found for which the body shape is a sphere concentric with the shock. The stand-off distance of the shock and the pressure relief on the body increase with increasing magnetic-field strength.

From author's summary by D. W. Holder, England

5780. Meyer, R. C., On reducing aerodynamic heat-transfer rates by magnetohydrodynamic techniques, *J. Aero/Space Sci.* **25**, 9, 561–566, 572, Sept. 1958.

Paper considers theoretically the reduction of stagnation point heat transfer on a blunt body at hypersonic speeds by the use of a magnetic field. The modifications to the flows inside and outside

the viscous boundary layer are considered, and it is concluded that the effect on the external flow is primarily responsible for the reduction of heat transfer. The existence of a magnetic-fluid boundary layer is demonstrated for fluids of high electrical conductivity, and it is shown that the theory for this layer resembles that for a viscous boundary layer.

For a flat plate, a simple investigation suggests that magnetic techniques are unlikely to have a significant effect on heat transfer unless the electrical conductivity of air is artificially enhanced.

A critical review of this and other papers on the effects of magnetic fields on boundary-layer flows is given by Hess in *NASA Memo* 4-9-59L. D. W. Holder, England

5781. Udy, L. L., Propagation characteristics of detonation generated plasmas, AFOSR TN 58-754 (Univ. Utah, Explosives Res. Group; ASTIA AD 201 613), 32 pp., June 1958.

Electrical conduction measurements were made in the highly ionized plasma region produced by detonating high explosives. The plasma was determined to originate directly from reaction of the high explosive rather than from thermal ionization associated with the accompanying shock wave. The mechanism of conduction was considered, and it was shown that electron flow through the plasma accounted for practically all of the current. With this in mind, it was concluded that the current flow through the plasma region was of the same nature as current flow in a metal. Conduction measurements in atmospheres of chlorine, oxygen, nitrogen, helium, and air showed that the rate of decay of the plasma was dependent upon the gaseous medium and can be explained on the basis of negative ion formation. The plasma exhibited pulsations and it was concluded that an adhesive attraction exists in the plasma through a quasi-lattice structure. Electron densities of 10^{16} electrons/cc were calculated from conduction measurements of the plasma after it had spread from the 1-in. diameter charge to a 2-in. diameter constraining tube. From author's summary

Aeroelasticity

(See also Rev. 5717)

5782. Broadbent, E. G., Aeroelastic problems associated with high speeds and high temperature, *J. Roy. Aero. Soc.* **62,** 576, 867-872, Dec. 1958.

Author treats the effects of chordwise distortion on aeroelastic phenomena. Two simple examples are presented to illustrate these effects. The first deals with static distortion of a solid, biconvex, rectangular wing with leading and trailing edges at temperatures higher than mid-chord. Analysis is made using nonlinear relationships derived by Mansfield. In this case, chordwise distortion tends to stabilize any divergence, but lift is decreased considerably.

It is shown in the second example that chordwise distortion can reduce flutter speed of a flat plate. Brief mention is also made of panel flutter.

The author concludes, on the basis of these two extreme examples, that the effects discussed are unlikely to have a serious effect on design. E. K. Parks, USA

5783. Crisp, J. D. C., On the theory of flutter prevention for wing-flap systems, *Aero. Res. Lab. Melbourne, Austral., Rep.* SM 259, 106 pp., Jan. 1958.

Paper commences by considering techniques available for flutter analysis. Its main burden, however, is that of showing how the principle of equivalence of various flap configurations under a given flutter mode may be used to facilitate improvement of aeroelastic properties. Main cases considered are binary flutter combining flap motion (including twist) with either wing bending or torsion. Many illustrative curves are presented. A practical example is used to show effects of variation of main flap parameters. Extension of techniques to higher-order cases is indicated.

Treatment is detailed, and a condensed and more readable version may be found in AMR **12** (1959), Rev. 3107.

K. H. Griffin, England

5784. Shioiri, J., Non-stall normal mode flutter in annular cascade. Part I, Theoretical study; Part II, Experimental study, *Trans. Japan Soc. Aero. Engng.* **1,** 1, 26-45, 1958.

It is shown that typical blades of modern axial-flow machines, forming annular cascade and having high ratio between the mass per unit length and the product of the air density with the square of the semichord of the blade, can get into special kind of flutter, called the non-stall normal flutter, arising from the mutual interference among the blades due to the steady components of bound vorticity distributions. The vibrations of the blades in this case have the same shape, identical with one of the normal mode of the blade; also the common frequency is nearly equal to the natural frequency of the normal mode. The theory introduced is verified by experiments. Comparison between results of measurements and theoretical predictions show fairly good agreement.

V. Kopriva, Czechoslovakia

Aeronautics

(See Rev. 5782)

Astronautics

(See also Revs. 5659, 5753)

Book—5785. Proceedings of the first symposium on high altitude and satellite rockets, Cranfield, England, July 1957; New York, Philosophical Library, Inc., 1959, 136 pp. $15.

Book reflects the status of British-American applied science in the space-flight realm just prior to the tremendous impetus of the first Sputnik. The interest it derives from this fact is offset to a considerable extent by the obsolescence resulting from a nearly two-year delay in publication. So great has been the progress during these two years that a detailed critical review of these collected papers would be unfair.

Twelve papers are given, four authored by Americans. There are competent initial discussions of the scientific uses of satellites, the Vanguard rockets, the British sounding rocket "Skylark." These are followed by more general discussions of rocket propulsion and design, several interesting papers dealing with biological, physiological, and psychological problems, a survey paper on instrumentation, telemetry, and guidance, and three papers dealing with reentry, one of which considers high-temperature structures and materials.

The American paper on large rockets by K. D. Bossart of Convair appears to be especially noteworthy. Reflecting the wisdom and experience gained in the Atlas development, it is of equal interest to propulsion experts and to nonspecialists alike.

Viewed in the light of the rapid progress of the past two years, the three papers which discuss reentry-vehicle heating and structures problems will be of little value to specialists and possibly misleading to nonspecialists. J. V. Becker, USA

Book—5786. Dow, R. B., Fundamentals of advanced missiles, New York, John Wiley & Sons, Inc., 1958, xvi + 567 pp. $11.75.

Author, in preparing this book, chose for his goal an orderly presentation of the fundamental physical and mathematical princi-

ples required for adequate comprehension of guided missile technology. These principles are woven together in a direct and readable fashion for the use of anyone with a specialized engineering background who wishes to broaden his understanding of advanced missile systems. Most of the material is concerned with problems of guided flight within the atmosphere, a field in which Mr. Dow has been active for over a decade. For those interested primarily in ballistic missiles and satellite vehicles, there is also much of value in connection with the ascent phase and on communications.

Chapter I reviews the kinetics of flight. Coordinate systems, notation and the simplest idealized flight courses are described. Chapters 2–6 on Fluid mechanics, Dynamics, Probability and statistics, Microwaves and infrared, respectively, each start with the basic principles of the discipline and develop in simplified terms materials relevant to applications for guided missiles. In discussing the well-known Prandtl-Meyer expansion of a supersonic stream, for example, author presents only the straightforward linearized theory and provides the reader with an adequate reference to the full analytical development. Where relevant, data are given on the actual performance of existing instrumentation and hardware devices. Chapter 7, Radar, and 8 Guidance, cover the functions and present-day limitations of these subsystems. At this point in the book, the reader is well advised to return to the second half of the chapter on dynamics for review of the interplay between the elements making up the entire missile operating loop.

If any lack is to be found in the book it is the absence of this integration of the material presented in the first eight chapters. Chapter 9 on Systems could well accomplish such an objective but is too brief to include much more than generalities.

This reviewer feels that the author has done a creditable job on a subject fraught with the hazards of rapid change in national policy and technology. An overabundance of footnotes should perhaps be collected at the end of each chapter or incorporated into the text so as to give the reader better continuity of material.

W. C. Griffith, USA

The following series of papers appeared as a feature in November 1958 *issue of* Astronautics *under the heading* "State of the Art."

5787. Ehricke, K. A., Space flight, 3, 11, 46–48, 124–128.

5788. Lee, Y. C., Liquid rockets, 3, 11, 50–51, 134.

5789. Tuhy, I. E., Solid rockets, 3, 11, 52–53, 90.

5790. Brown, L. S., Instrumentation and guidance, 3, 11, 54–55, 136.

5791. Sloop, J. L., Propellants and combustions, 3, 11, 56–57, 143.

5792. Simons, D. G., Human factors, 3, 11, 58–59, 77.

5793. Morris, B. T., Ramjets, 3, 11, 60–61, 140–142.

5794. Krotov, V. F., Calculation of the optimum trajectory for the entry of a rocket into a particular circular trajectory (orbit) around the earth (in Russian), Mekhanika (MVTU no. 50), Moscow, Oborongiz, 1956, 313–334; *Ref. Zh. Mekh.* no. 2, 1958, Rev. 1541.

The variational problem is examined of finding the conditions of fuel consumption enabling a ballistic missile (rocket) to be guided into a given orbit with minimum starting weight, on the condition that the thrust is always co-directional with the velocity of the missile. It is assumed that the required trajectory consists of a section representing the initial impulse, an active section, a passive section, and a section of final impulse. Applying the equations of motion in projection on the tangent and normal to the trajectory, the argument is constituted by the geocentric radius r, although no proof is given that the function $r(t)$ is in fact monotonous along the solution. The variability of g with altitude and the counterpressure are allowed for by the method suggested by D. E. Okhotsimsky [*Prikl. Mat. Mekh.* 1946, no. 2], but author presents this method as original and maintains that until it appeared these factors were neglected. In the equations of motion, the density of the atmosphere depends on the altitude, and they contain terms for the centrifugal and Coriolis forces. Author has not noticed, however, that the equations as written are valid only for the case that the given orbit is in the plane of the Equator. His assertion of the applicability of the method of solution for "calculating the transition into any given, cosmic trajectory" is erroneous. The final mass of the rocket is assumed given, while the functional term of the problem, M_0 (initial mass), is found by integrating the Meshchersky equation in projection on the tangent. The equation in the projection on the normal is regarded as a nonholonomial linkage, and the problem is reduced to the general Lagrange problem. The variational problem for the active section is reduced to solution of the boundary problem for a system of two differential equations (of the 1st and 3rd order). However, the derivation of the boundary conditions is incorrect, since the author does not consider the mobility of the beginning of the active section. The solution of the boundary problem is suggested by a particular method. The possibility of obtaining a solution by this method is not rigorously demonstrated; no proof is given that the solution sought in fact represents the minimum, and the question whether it is unique is not in fact touched upon.

Author gives no analysis of the equations set up, the properties or singularities of the optimum motion, and does not examine any examples. There are misprints, inaccurate statements and errors in reasoning; the formulas are not always correctly explained in the text.

B. A. Saryichev and B. A. Egorov

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

5795. Egorov, V. A., On the solution of a degenerate variational problem and the optimum climb of cosmic (space) rocket, *Appl. Math. Mech. (Prikl. Math. Mekh.)* **22,** 1, 20–36, 1958. (Reprint order no. PMM 2, Pergamon Press, 122 E. 55th St., New York 22, N.Y.

Paper contains a solution of Mayer's problem for Pfaff's equation with one free function, and is applicable to the selection of the climbing trajectory of a rocket to a given altitude with maximum speed. The indicated problem is formulated in Section 1. It is shown that the problem of the rocket flight without induced drag and of its motion, with zero angle of attack, on a rigid, ideally smooth track, are reducible to the formulated problem, which is proved to be a degenerate one. In Section 2 the variational problem is investigated and a general solution to it is given, as well as basic special cases. In Section 3 the application of the general solution to the problem of rocket climb yields the optimum trajectory. The case of the motion on a launching track (ramp) is considered separately.

From author's summary by A. Miele, USA

5796. Kotov, V. F., The theory of a new type of rocket (in Russian), *Trudi Odessk. In-ta* **146,** *Ser. Matem. Nauk* no. 6, 79–84, 1956; *Ref. Zh. Mekh.* no. 2, 1958, Rev. 1731.

Author first recapitulates in simpler form the derivation of the relativistic equation of motion of a photon rocket, first set up by Seager. Next, he gives a derivation of the classical equation of motion of the photon rocket, on the assumption that its velocity has an upper limit and is everywhere below the speed of light. Further, the theory of the atomic rocket is developed in the conventional approximation, taking into account that not only "defective" mass but also inert "slag" mass will be ejected.

K. P. Stanyukovich

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

Ballistics, Explosions

(See also Rev. 5795)

5797. Andriankin, E. I., Strong explosions in a medium with a pressure gradient (in Russian), *Izv. Akad. Nauk SSSR, Otd. Tekh. Nauk* no. 2, 123–125, Feb. 1958.

Author considers a point explosion in a medium with a pressure gradient but with the initial density everywhere constant. For simplicity, author considers the axially symmetric case and concludes that his reasoning is valid for the general case of the problem of strong shock waves, which are close to spherical or cylindrical shape. T. Riabokin, USA

5798. Okhotsimskii, D. E., Kondrasheva, I. L., Vlasova, Z. P., and Kazakova, R. K., Calculations for a precision explosion, taking into account the counter-resistance (in Russian), *Trudi Matem. In-ta Akad. Nauk SSSR* no. 50, 66 pp. + illus., 1957; *Ref. Zh. Mekh.* no. 3, 1958, Rev. 2659.

Results are given of the solution of the problem of a precision explosion in an immovable medium with constant values of the initial density ρ_0 and pressure p_0. The equations for a one-dimensional unsteady adiabatic motion of a perfect ideal gas with Lagrangian independent variables and some specially selected functions are assumed. Further, it is assumed that the distribution of the sought functions at some sufficiently approximate moment of time in relation to the explosion can be obtained from L. I. Sedov's solution of the automodel problem regarding an explosion without consideration of the counterpressure. One of the schemes used for the calculations is set forth; here the intervals $\Delta\sigma$ remain constant while the time step $\Delta\tau$ is selected from the condition $\Delta\tau = \Delta\sigma/(c$ being the velocity of the shock wave at the moment of time being investigated). Near the explosion center, because of the presence of unusual features, use was made of symptotic formulas describing the behavior of the sought functions. The magnitude of the central interval was selected by means of the required condition of a smooth union with the asymptotic solution. The calculations were carried out for the indicator of the adiabate $\gamma = 1.4$. Detailed tables and graphs are provided. The special features of the change in the characteristics of the motions of a gas in time are discussed. The satisfactory coincidence between the results of calculations and the self-modelling solution at the earliest stage of the explosion and the extremely slow deformation of the profile of the wave as it degenerates are noted.

The same problem was concurrently solved by different methods by Goldstein and Neumann [Goldstain, H., Neumann, J., *Comm. Pure Appl. Math.* **8**, 327–354, 1955] and Brode [Brode, H., *J. Appl. Phys.* **26**, 6, 766–775, 1955]. A comparison of the results obtained with the results of the first of these works shows good agreement, but in the work under review the calculations required a smaller number of reference points for the time coordinate.

M. L. Lidov

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

5799. Pokrovsky, G. I., Fundamental postulates for the calculation of heavy charges of BB for blasting (in Russian), Vzryv. Raboty no. 3, Moscow, Promstroyizdat, 1956, 6–22; *Ref. Zh. Mekh.* no. 2, 1958, Rev. 1656.

A formula is set up for calculating the weight of charge required to blast out soil for a given length of line of least resistance of the soil to blasting. As the author shows, with great length of this line of least resistance this formula gives more accurate results than the Boreskov formula. The experimental data are appended.

G. S. Migirenko

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

5800. Johnson, O. T., Olson, W. C., and Patterson, J. D., II, A simple mechanical method for measuring the reflected impulse of air blast waves, Proc. Third U. S. Nat. Congr. Appl. Mech., June 1958; Amer. Soc. Mech. Engrs., 1958, 203–207.

A mechanical method is described for measuring the impulse imparted to a flat rigid surface by the reflection (at normal incidence) of an air blast wave. The method consists of measuring the velocity at which a cylindrical plug of known mass is projected from a hole in a large rigid surface by a normally incident blast wave and computing the impulse from Newton's second law.

Experimental results were obtained for spherical Pentolite explosive charges ranging in weight from ¼ to 2 lbs. and scaled distances from 0.5 to 2.5 ft/lb.$^{1/3}$. Results are tabulated and presented graphically. In addition, a comparison is made with data obtained with piezoelectric gages. From authors' summary

Acoustics

(See also Revs. 5506, 5575, 5631, 5684, 5732, 5761, 5765)

5801. Muller, E.-A., and Matschat, K., On the production of noise from decaying homogeneous isotropic turbulence (in German), *Z. Flugwiss.* **6**, 6, 161–170, June 1958.

In earlier analysis Proudman [AMR **6** (1953), Rev. 2591] applied Lighthill's theory of aerodynamic sound [AMR **6** (1953), Rev. 654] to calculate noise power generated per unit mass of homogeneous isotropic turbulence. Result was of form $P = \alpha\bar{u^2}^4/(\text{sound speed})^5 \times (\text{scale})$. He found $\alpha \approx 38$ based on application of Heisenberg's theoretical spectrum of turbulence. Present authors give a resumé—in considerable detail—of Proudman's analysis up to point of evaluating α (which they call γ). Then they make extension to yield dependence of α on time (Heisenberg's integrodifferential equation for the decay is solved numerically for a rectangular assumed starting spectrum). Power is integrated to give total sound energy E emitted during decay in form $E/M^5 \times$ (initial turbulent energy) = fraction of Reynolds number based on scale, Re_L. Ten-fold decreases in Re_L yields two- to three-fold decrease in E.

Authors infer therefrom that reduction in eddy size may be important factor in attenuation provided by some jet noise suppressors. Reviewer disagrees on ground eighth-power contribution of turbulent velocity far outweighs weak effect of eddy size.

H. S. Ribner, Canada

5802. Ustinenko, L. V., The acoustic field of an irregularly-moving source of sound (in Ukrainian), Nauk. Pratsi Kharkovsk. In-ta Inzh. Komun. Budivnitstva no. 7, 177–183, 1956; *Ref. Zh. Mekh.* no. 2, 1958, Rev. 1665.

The field is examined of a source of arbitrary shape and magnitude, moving with subsonic velocity. The conception of the center of intensity of a source is introduced:

$$r_c = \frac{1}{Q}\int \bar{q} r ds \qquad \left(q = \frac{dQ}{ds}\right)$$

where Q is a function determining the strength and direction of the source. The value of the velocity potential in an arbitrary point of the field is written in the form of the potential of a moving point source of sound of corresponding power and direction.

A. A. Kaspar'yants

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

5803. Ting, L., On the diffraction of an arbitrary pulse by a wedge or a cone, AFOSR TN 59-127 (Polyt. Inst. Brooklyn, Dept. Aero. Engng. Appl. Mech. Rep. 502; ASTIA AD 210 615), 12 pp., Feb. 1959.

By virtue of Green's theorem, it is shown that for the diffraction of an arbitrary two-dimensional incident pulse by a wedge of angle μ, ratio of the resultant velocity potential to the corresponding value of the incident pulse at the corner of the wedge at any instant is equal to $2\pi/(2\pi - \mu)$; and that for the diffraction of a three-dimensional pulse by a cone of solid angle ω, the ratio at the vertex of the cone is equal to $4\pi/(4\pi - \omega)$.

From author's summary

5804. Richardson, E. G., Velocity of ultrasonics in halogen vapors, *J. Acoust. Soc. Amer.* **31,** 2, 152–154, Feb. 1959.

The limiting values of the velocity of sound for high and low frequencies in the halogens in the gaseous state have been calculated. Measurements at ultrasonic frequencies in three gases have confirmed dispersion of the velocity with relaxation times in the vicinity of 10^{-6} sec. From author's summary

5805. Maglieri, D. J., Shielding flap type jet engine noise suppressor, *J. Acoust. Soc. Amer.* **31,** 4, 420–422, Apr. 1959.

Far-field noise measurements from model tests of a shielding-flap-type jet noise suppressor are presented in the form of radiation patterns and frequency spectra. The tests were conducted using a cold air jet issuing from the nozzle in such a manner as to attach to and flow along the surface of a shielding flap. Whereas other proposed noise suppressors provide generally symmetrical noise radiation patterns, the present device skews the pattern in a beneficial way such that large noise reductions are obtained in the downward direction. These large noise reductions are thought to result from both the acoustic shielding of the flap and the benefits of flow attachment. From author's summary

5806. Wisniowski, H. U., Experiments with screens and grids for suppressing jet engine noise, *Nat. Aero. Establ., Canada, Lab. Rep.* 231, 29 pp., Oct. 1958.

Experiments were made with noise suppressors of conventional screen and newly developed grid type. These devices were installed in an exhaust duct of a jet-engine test cell. The sound level reductions obtained which could be applied practically amounted to 16-1/2 db. Higher reductions (up to 20 db) were penalized by the adverse influence of the suppressor on tailpipe temperature and engine thrust. From author's summary

Micromeritics

5807. Binark, H., and Ranz, W. E., Quick method for measuring drop size of hollow cone sprays, *Indust. Engng. Chem.* **51,** 5, 701–702, May 1959.

Method consists of establishing an air flow through the spray cone, at right angle to the latter, whereby the spray droplets are deflected from their direction along the cone to a direction parallel to the cone axis; smaller drops having shorter stopping distance move near the axis, and larger drops having longer stopping distance move far from the axis; by determining the quantitative distribution across the deflected spray, i.e., perpendicularly to the spray axis, a curve representing the spray flux versus radial distance can be drawn; from this curve, with the additional determination of the initial jet velocity, and using some basic aerodynamic equations for the motion of small spheres, the drop-size distribution curve can be plotted. Experimental apparatus is illustrated and described; procedure is explained; motion of a spherical drop in still gas solely under influence of aerodynamic forces is given by equation and is also represented graphically.

This is a well-conceived investigation, having importance for processes such as spray evaporation, spray drying, and fuel spray combustion. K. J. DeJuhasz, Germany

5808. Ryley, D. J., Experimental determination of the atomising efficiency of a high-speed spinning disk atomiser, *Brit. J. Appl. Phys.* **10,** 2, 93–97, Feb. 1959.

Electrically driven disks of 3 and 5-cm diameter were rotated at 20,000 to 60,000 rpm, and samples of aqueous spray were analyzed for flow rates of 0.12, 0.42 and 0.77 cu.cm/s. The reduction of disk speed during atomizing was determined experimentally using an electronic pulse counter, and a miniature dynamometer was devised to simulate this reduction and measure the power absorbed. Atomizing efficiencies for the electrically driven disk thus obtained are compared with the efficiency employing air drive, and also with that of a simple pressure atomizer. In all cases, efficiencies are less than 0.5 per cent. Method used was to observe the speed reduction produced by the application of the atomizing load, and then to employ a suitable brake on disk when dry to produce the same speed reduction. Difficulties are (a) the speed reduction is extremely small, and (b) the power to be absorbed by the brake is far below the capacity of orthodox instruments. A miniature rope brake was used; this is described and illustrated. Experimental results are given in sets of curves. The energy imparted to the liquid is expended on (a) creating new surface, (b) providing kinetic energy to the flung globules, and (c) deformation of globules and ligaments resulting in internal heating. Previous work, May 1949 and Hinze and Milborn, 1948, is discussed.

K. J. DeJuhasz, Germany

5809. Lastovtsev, A. M., The throughput capacity of rotary atomizers (in Russian), *Trudi Mosk. In-ta Khim. Mashinostr.* **11,** 71–82, 1957; *Ref. Zh. Mekh.* no. 2, 1958, Rev. 1842.

An experimental determination of the relationship between the limiting volumetric throughput of an atomizer Q_n and its angular velocity, cross-sectional area of the orifice, number of orifices, radius of the intake orifices of the receiving chamber, and the radius of the receiving chamber in the plane of the orifices through which the liquid issues. Also verified is the influence on Q_n of the length of the atomizer channels, the construction of the receiving or intake chamber, and the physical properties of the working fluid. Atomizers of 19 different sizes were tested. A formula has been obtained for calculating the limiting throughput capacity of rotary atomizers. K. K. Vasilevskii

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

5810. Lastovtsev, A. M., The hydrodynamic analysis of rotating atomizers (in Russian), *Trudi Mosk. In-ta Khim. Mashinostr.* **11,** 41–70, 1957; *Ref. Zh. Mekh.* no. 2, 1958, Rev. 1841.

The motion of a fluid in rotating atomizers with variously directed orifices, cross sections and profiles is examined. The following assumptions are made: (a) Friction between the free surface of the liquid in the atomizer channel and the air is negligible; (b) the transverse components of the flow velocity are negligible; (c) the liquid moves without hydraulic pressure, merely by the action of centrifugal inertia forces. A differential equation is derived for the turbulent flow of a liquid in an atomizer. Analytical expressions are set up for determining the relative velocity of the liquid at the edge of the atomizer. It is found experimentally that the expressions obtained are applicable in a wide range of variation of the angular velocities and dimensions in the atomizers, as well as the loads in the channels. K. K. Vasilevskii

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

Porous Media

5811. Hertzberg, A. M., and Mountfort, C. B., The measurement of filterability and a method for design of a factory filter station, *Trans. Instn. Chem. Engrs.* **37**, 1, 5–8, Feb. 1959.

The method has been developed primarily for the sugar refining industry where large volumes of sugar solution must be filtered in the most economical way; but it is applicable also to filtering problems in other industries. The analysis is based on prior work of Carman; all factors affecting the performance of batch filters have been considered, and the output is expressed as a function of those factors. An important variable in the relationship is the filtering characteristics of the slurry, termed the "slurry resistance," which had to be defined and measured. In the general case of compressible filter cakes, the slurry resistance is a function of the filtration pressure. The factors influencing the separation of the solid and liquid phases of a slurry can be divided into those concerning the solid phase (specific surface area and porosity of the cake), and those concerning the liquid phase (viscosity, density of solution, and concentration of solute therein). These factors are expressed mathematically, and with them the differential equation of the filtering process is expressed. Equations for constant dry-rate filtration are developed and their use illustrated with a numerical example.

This is a report on a theory having practical applicability, based on industrial experience in sugar refining; the use of numerical examples is clarifying and commendable.

K. J. DeJuhasz, Germany

5812. Juhasz, J., Investigation of infiltration, Parts I and II (in Hungarian), *Hidrológiai Közlöny* **38**, 4, 262–272, Aug. 1958; **38**, 5, 343–351, Oct. 1958.

5813. Sichinava, O. A., Calculation for the filtration coefficient and for losses (in irrigation) (in Russian), *Nauch. Trudi Stud. Gruz. S. -kh. In-ta* **6/7**, 138–144, 1957; *Ref. Zh. Mekh.* no. 4, 1958, Rev. 4335.

Elementary concepts and formulas relating to the theory of filtration are furnished. The method is described as used by the author for the determination of the coefficient of filtration and of losses on a temporary irrigation canal 200 m long and with a discharge of 20 *l*/sec. Observations and measurements were made over a period of 2 days, and for 6 hours each day. The following empirical relations were recommended, to suit the given conditions and locality, for the change of filtration coefficient and loss with time

$$K_t = \frac{0.0018}{t^{0.5}}\ \text{m/sec.} \qquad \sigma = \frac{50}{t^{0.5}}$$

where t is the time in hours and σ is the loss in % over a distance of 1 km. Author shows that the obtained empirical formulas are in agreement with the formulas of other authors for canals with small discharges. The experiments were carried out in conditions of irregular filtration, consequently the coefficients obtained by the author have to be viewed as conditional coefficients of filtration taking into account the wetting through of the soil and other factors. In the table compiled from the results and their analysis, the dimensions of the hydraulic elements of the canal measured during the experiments are omitted, which makes it difficult to make use of the original data.

A. G. Chanishvili

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

5814. Murashko, M. G., Mass exchange in capillary-porous partially delimited media (in Russian), Avtoref. Diss. Dokt. Tekhn. Nauk, Moskov. Tekhnol. In-ta Pishch. Prom-sti, Moscow, 1957; *Ref. Zh. Mekh.* no. 4, 1958, Rev. 4340.

5815. Tretyakov, M. V., The flow of an ideal fluid round a permeable plate in the presence of a plane-parallel potential at finite angles of incidence (in Russian), *Ucb. Zap. Udmurtsk. Gos. Ped. In-ta* no. 8, 63–75, 1956; *Ref. Zh. Mekh.* no. 2, 1958, Rev. 1833.

The problem indicated in the title is solved on the assumption that at each point of the plate there exists between the pressure gradient and the rate of penetration V_i a linear relationship termed the law of penetration

$$\Delta p = aV_i \qquad [1.1]$$

Applying the Bernoulli-Euler integral, author reduces Eq. [1.1] to the form

$$(\rho/2)(V_\tau^+ - V_\tau^-)(V_\tau^+ + V_\tau^-) = aV_i \qquad [1.4]$$

where V_τ^+, V_τ^- are the tangent velocities. Regarding the plate as a surface formed by continuously distributed vortices, author obtains from Eq. [1.4] a singular integral equation with a nucleus of the Cauchy type for determining the intensities of the vortices γ. The solution of the latter is found by a method indicated by Mikhlin ["Integral equations," Gostekhizdat, 1947]. A formula is derived for the rate of penetration V_i, and the shape of the streamlines determined by a method of numerical calculation.

G. G. Tumashev

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

5816. Tretyakov, M. V., The flow around a permeable semi-circumference (in Russian), *Ucb. Zap. Udmursk. Ped. In-ta* no. 8, 119–146, 1956; *Ref. Zh. Mekh.* no. 2, 1958, Rev. 1834.

The problems of flow around an arc of a plane-parallel, steady flow of an ideal fluid are examined. It is assumed that at each point on the arc the pressure drop Δp is proportional to the rate of penetration V_i. Applying the Bernoulli-Euler integral, author reduces this relationship to the form

$$\frac{\rho}{2}(V_\tau^+ + V_\tau^-)(V_\tau^+ - V_\tau^-) = aV_i \qquad [1.4]$$

where V_τ^+, V_τ^- are the projections of the velocity on the tangent to the arc. Examining the case of an arc symmetrical to an axis parallel to the velocity of the undisturbed flow, and considering it as a line of continuously distributed vortices, author derives from Eq. [1.4], the integral equation for the intensity of the vortices γ. The case is examined in detail in which the arc is a semicircle. The solution of the corresponding integral equation with a nucleus of the Cauchy type is obtained by the method of Mushkelishvili [S. N. Mushkelishvili: "Singular integral equations," Gostekhizdat, 1946]. For small values of the parameter

$$\alpha = \frac{2\rho V_\infty \sqrt{R^2 - x^2}}{aR}; \text{ where } \frac{2\rho V_\infty}{a} < 1$$

and neglecting quantities of the order of α^3, author obtains the approximate expression for γ. The form of the stream lines is obtained by a method of numerical integration of the equations.

G. G. Tumashev

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

5817. Pirverdyan, A. A., and Ambartsumyan, A. P., The hydrodynamic analysis of some methods of influencing strata (in Azerb.), *AzerbSSR Elmler Akad. Kheberleri (Izv. Akad. Nauk AzerbSSR)*, no. 2, 15–22, 1957; *Ref. Zh. Mekh.* no. 2, 1958, Rev. 2022.

Problems are investigated of the filtration of a liquid in a stratum with rectilinear and annular arrays of extraction and pressure boreholes in conditions of a rigid water-pressure condition,

the expulsion pressure being applied both outside (at) the contour and within the same. This is founded on the method of equivalent filtration resistances developed by I. A. Charny: "Fundamentals of underground hydraulics," Gostoptekhizdat, 1956. The following cases are analyzed: (a) In a stratum bounded on three sides by impermeable limits, there are arranged m rows of extraction, and one row of pressure boreholes. Pressure is applied both beyond (at) the contour and from the side of the impermeable boundary. Assuming the pressures in the boreholes and at the feeding contour to be known, authors set up a system of equations determining the discharges from the extraction rows, and the amount of leakage of the liquid beyond the contour for both methods of pressure application. (b) A detailed investigation is made of the cases when $m = 2$, and $m = 1$. (c) Authors point out that the structure of the equations of discharge and leakage losses for annular arrays coincides with the structure of the analogous expressions for rectilinear rows, and that the analog of water-flooding from the side of the impermeable boundary is the case of central flooding. For the case of $m = 1$, the problem of the expulsion pressure values is examined.

V. A. Karpyichev

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

5818. Nassberg, V. M., and Elbakidze, M. G., Calculation of the coefficient of filtration of concrete of brands B2, B4 and B8, determined according to USSR Standard Specification GOST 4795-53 (in Russian), *Izv. Tbilissk. N.-i- In-ta Sooruzb. i Gidroenerg.* **9**, 7-89, 1955; *Ref. Zh. Mekh.* no. 2, 1958, Rev. 2024.

The defects of determination of the water-permeability of concrete by the method of GOST 4795-53 are pointed out. A method developed by the authors is suggested for determining the water-permeability of concrete, calculating the value of the coefficient of filtration by the formulas for unsteady-state filtration. By this method, the approximate values of the coefficients of filtration for (standard) concrete of grades B2, B4 and B8 are calculated for degrees of pressure and test duration, as provided in the GOST specification. At the same time, some supplementary considerations are presented, affording more rigorous standards for the storage and testing of concrete samples for water permeability. The suggested method is more progressive than the existing method of evaluating water-permeability in concrete according to the GOST specifications. In the abstractor's opinion, it would be better to test concrete, as, indeed, any other water-permeable material, by measuring the filtration in the steady state, as is already done at present in the investigation of the filtration properties of cement clinker [cf. *Izv. Vses. N.-i. In-ta Gidrotekhn.*, no. 56, 1956].

A. N. Adamovich

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

5819. Vakhitov, G. G., Solution of problems on underground hydrodynamics by the method of finite differences (in Russian), *Trudl Vses. Neftegaz. Nauk i. In-ta* no. 10, 53-87, 1957; *Ref. Zh. Mekh.* no. 4, 1958, Rev. 4329.

An investigation is made regarding the application of the method of finite differences for the solution of problems of filtration of a liquid in complete and incomplete wells in a heterogeneous layer as regards physical parameters, with an arbitrary form of contour for the source of feed. The filtration region D agrees approximately with the network region the boundary points of which may be within as well as outside D. The boundary conditions on the source of feed contour are transposed onto the boundary of the network region by means of interpolation. The wells are examined as points and are located in the joints of the network. A method is devised for the determination of the pressure field and velocities in the heterogeneous layer during the working of the exploitation and delivery wells. When determining the wells' output a correcting coefficient is brought in, determined theoretically, which takes into account the actual diameters of the wells. The question is investigated of the selection of the optimum spacing of the network. The accuracy of the results obtained is demonstrated by means of a large number of examples.

P. F. Fil'chakov

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

5820. Salkhov, G. S., Solution of problems of control by movement of the contour of the oil-bearing stratum, using the method of trigonometrical approximation (in Russian), *Izv. Kazansk. Fil. Akad. Nauk SSSR, Ser. Fiz.-Mat. Tekhn. Nauk* no. 11, 15-22, 1957; *Ref. Zh. Mekh.* no. 4, 1958, Rev. 4330.

The article is a continuation of previous work by the author. The case is examined of a horizontal layer, possessing everywhere in its petroleum-bearing area constant power and permeability, with a water-pressure system operating. The viscosity of the petroleum and water is assumed to be the same, while the movement obeys the linear principle of filtration. For the solution an investigation is made of the non-viscid expression $\epsilon = \bar{V}_n - V_n$, where $\bar{V}_n$ and V_n are the given and actual normal velocities of the transposition of the contour of the oil-bearing layer. The non-viscid expression

$$\epsilon = \epsilon\,(\theta, r, t, \varphi_1, \ldots, \varphi_{n+l}; \rho_1, \ldots, \rho_{n+l}; q_1, \ldots, q_{n+l})$$

is the known function of error, depending on $3(n + l)$ parameters: (φ_i, ρ_i) are the polar coordinates of the wells and q_i the flowing volumetric output of the wells. Indices $i = 1, \ldots, n$ correspond to the exploitation, while indices $i = n + 1, \ldots, n + l$ to the pressure wells. Assuming that, in accordance with the given principle, the tightening round ϵ is a sufficiently smooth function of the arc abscissa of the contour of the petroleum-bearing area, author resolves the non-viscid ϵ into a Fourier series and then determines the unknown parameters φ_i, ρ_i, q_i from the condition that the first coefficients of the series obtained are equal to zero. The permissible mean quadratic error, in this procedure, in the divergence of velocities V_n and $\bar{V}_n$ is determined from Parseval's parity. The possibility is examined of the superposition of solutions of several problems of control having identical principles for the tightening of the contour of the petroleum-bearing area and, in particular, for petroleum deposits with a large number of wells. The following theorem is substantiated: If on the petroleum-bearing site $n_1 + \ldots + n_N$ wells are located along coordinates $(\varphi_{ij}, \rho_{ij})$ $(i = 1, \ldots, n_j, j = 1, \ldots, N)$ and their output determined (with arbitrary $c_j > 0$) by the formula

$$\tilde{q}_{ij} = c_j q_{ij} \left(\sum_{j=1}^{N} c_j \right)^{-1}$$

then the general mean quadratic error I will not exceed the maximum values of the mean quadratic errors I_j $(j = 1, \ldots, N)$, obtained when solving separately the control problems corresponding with the number of wells n_j $(j = 1, 2, \ldots, N)$; $I < \bar{I} = \max\{I_1, \ldots, I_N\}$.

P. F. Fil'chakov

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

5821. Melzer, A., Problems of model analysis of ground water flow investigation (in Hungarian), *Hidrológiai Kőzlöny* **38**, 5, 352-358, Oct. 1958.

5822. Ghadzhieva, M. G., The steady-state filtration of gasified petroleum (in Azerb.), *Trudl In-ta Fiz. i Mat. Akad. Nauk AzerbSSR* **7**, 66-70, 1955; *Ref. Zh. Mekh.* no. 2, 1958, Rev. 2018.

The steady-state motion of a gasified (gas-laden) liquid in a porous medium is investigated. Author takes into consideration the change in the real properties of stratified liquids. Applying the function of S. A. Khristianovich [*Prikl. Mat. Mekh.* **5**, no. 2, 1941] the calculation of the steady motion is resolved to solution

of the Laplace equation. In the solution of the problem, author introduces the effect of gravitation. Similarly to several preceding investigations, however, this is done purely formally, with allowing for the rising of the gas through the petroleum. The problem of the steady motion of gasified petroleum in the general form, but without formal introduction of the gravitational force, has already been investigated by L. A. Zinovieva [*Tr. Vses. Neftegaz. N. -i. In-ta*, no. 6, 254–269, 1954]. M. D. Rozenburg

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

5823. Kovacs, Gy., Theoretical investigations on micro-seepage (in Hungarian), *Hidrológiai Közlöny* **37**, 3, 210–222, 1957.

The range of validity of Darcy's law is investigated. Recent development in the theoretical and experimental study of micro-seepage is reviewed. Model law for seepage investigation is dealt with and the Mosonyi-Spronck invariant number is proposed. This number reads: $V \cdot \nu/l^2 \cdot g$ where V is the velocity, ν is kinematic viscosity, l representative length (such as the mean sand diameter), g is the acceleration of gravity.

Lower limit of validity of Darcy's law is induced by the increasing effect of molecular forces. The region where the molecular forces influence the seepage is called the region of micro-seepage. Exact mathematical analysis is given for this region, with the assumption that the molecular forces increase linearly in the diffuse double layer. A. L. Simon, USA

5824. Gudok, N. S., and Kusakov, M. M., Experimental investigation into the influence of external pressure upon the permeability of oil-bearing rocks, *Soviet Phys.-Doklady* **3**, 2, 259–261, Dec. 1958. (Translation of *Doklad' Nauk SSSR (N. S.)* **119**, 2, 229–232, Mar.-Apr. 1958 by Amer. Inst. Phys., Inc., New York, N. Y.)

5825. Savinov, S. F., Filtration of water in concrete dams built on poorly permeable foundations when drainage arrangements have been provided (in Russian), *Trudi Gor'kovsk. Inzh. -stroit. In-ta* no. 26, 63–89, 1957; *Ref. Zh. Mekh.* no. 4, 1958, Rev. 4334.

Paper represents an extensive experimental investigation on the study of the effect of drainage equipment of various kinds (horizontal galleries, vertical drainage of pressure faces, foundation drainage) on the character of the filtration of water through the body of concrete dams. Investigating the filtration of water through concrete as a process subordinated to d'Arcy's principle, and as moving through a homogeneous material, author carried out a large volume of experimental work on the EGDA apparatus. The marked influence was established of the horizontal galleries on the nature of the filtration in the body of the dam; as a result a recommendation is put forward that the horizontal galleries should be placed closer to the sole at a distance of 0,2 of the width of the dam from its outer face. The important positive role played by the vertical drains in overcoming the water saturation of the dam is pointed out. It is recommended that the drain diameters should be 0.25 m, with a distance between the drains not exceeding 1.5–2 m. A detailed study was made of the influence of the draining of the foundations on the decrease of counterpressure and on the reduction of the outlet gradients of the filtration flow. A series of measures of a constructive nature are proposed which would permit the rational location of drainage appliances in the foundations of concrete drains. Approximate formulas are given for drawing up designs for counterpressure when there is evidence of drainage in the foundation. A. A. Uginchus

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

5826. Tesarik, I., Turbulent flow through fluidized beds of identical spheres (in English), *Rozpravy Československé Akad. Věd* **66**, 6, 68–76, 1956.

Geophysics, Hydrology, Oceanography, Meteorology

(See also Revs. 5642, 5679, 5680)

Book—5827. Danilovich, V. N., Bases of the theory of deformation of geological bodies (in Russian), Irkutsk. Knizhn. Izd.-vo, 1953, 103 pp. + illus. gratis; *Ref. Zh. Mekh.* no. 3, 1958, Rev. 3302.

The application of modern expositions on the stressed and deformed states of bodies to some geological problems is examined. The mechanism of the deformation of geological bodies is analyzed in detail. Bekker's theory, devoted to the kinematic interpretation of the plastic stage in deformation, is explained. The conditions prevailing during crack formation are investigated. Based on the presentations put forward, several cases of deformation of stratum-forming bodies are examined. In the last two chapters of the book the connection between the structure of the rock and the character of the deformation is studied. The whole treatment of the subject is of an elementary nature. Yu. M. Liberman

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

5828. Urazbaev, M. T., Solution of the problem of stability of seismic effects of buildings in principal coordinates, taking into account the dissipation of energy (in Russian), *Izv. Akad. Nauk UzSSR, Ser. Tekhn. Nauk*, no. 2, 59–70, 1957; *Ref. Zh. Mekh.* no. 4, 1958, Rev. 4520.

Author holds the view that the dissipation of energy indicates a distortional effect on the form and phase of the vibrations along each frequency of the calculating parameters. For the basic frequence the distortion of the form of vibration is not great, since, in the period of time equal to one quarter of the period of the first form, the vibration process goes through all its characteristic stages for all the calculation parameters, while at the same time the amplitudes of all the higher forms decrease.

From author's summary

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

Book—5829. Jovanovic, S., Hydrometric current meter, its theory, rating and accuracy [Hidrometrisko krilo, teoriya, tariranye i tachnost primerenyi], Belgrade, Yugoslavia, Institute of Hydraulic Engineering, 1957, 106 pp.

A concise and comprehensive summary of modern knowledge on this important instrument. Two types of current meters are described; the screw type is treated in detail. Rating laboratories and rating process are described. Theory of runners, following L. A. Ott is presented. Also covered are: verification of accuracy of meter rated in calm water, when applied in turbulent flow; wave velocity and the Epper effect; accuracy of rating; accuracy of measurements; oblique currents, component runner; influence of lubrication and of water temperature. S. Kolupaila, USA

5830. Ishihara, T., and Takasao, T., Fundamental researches on the unit hydrograph method and its application (in Japanese), *Trans. Japan Soc. Civ. Engrs.* no. 60, 1–34, Mar. 1959.

The basic principle of the unit hydrograph method assumes that there exists a linear relation between the discharge $Q(t)$ and the rainfall $r(t)$ expressed as $Q(t) = \int_{-\infty}^{t} X(\tau) r(t-\tau) d\tau$, where $X(t)$ is the unit hydrograph given as a kernel of the linear integral equation. Since this expression is obviously based on empirical relations, the hydraulic significance of the unit hydrograph method will be lost unless a dynamical basis of the above expression is verified in the light of fluid mechanics.

Under these considerations, the present paper deals theoretically with the following two themes from a standpoint of hydraulics.

(1) Hydraulic significance of the fundamental principle of the unit hydrograph method.

(2) The most preferable elements of the unit rainfall and the unit hydrograph, and estimation of errors due to the application of the unit hydrograph method.

Authors hope that the results derived in the present paper will bring effective procedures to solve practical problems such as the range of applicability of the unit hydrograph method or the synthetic unit hydrograph, and so on.

From authors' summary

Courtesy, Editorial Committee of the Japan Society of Civil Engineers

5831. Lutkovsky, S. V., The problem of the formation of the temperature field of the sea in conditions of ebb and icing (in Russian), *Trudi Mor. Gidrofiz. In-ta, Akad. Nauk SSSR* **7**, 135–152, 1956; *Ref. Zh. Mekh.* no. 2, 1958, Rev. 1930.

A solution is given of the problem of temperature distribution in a shallow sea for a given balance of radiation at its surface and a constant temperature at a given depth of bottom. The eigenfunctions of the two-layer problem of heat conduction between the sea and the sea bottom are developed for constant values of the coefficients of thermal conductivity. The calculated results are compared with the actual temperature rate in the Azov Sea and Sea of Aral for the period from 1st June to 30th December. Agreement is found to be satisfactory. E. M. Dobryishman

5832. Phillips, O. M., Wave generation by turbulent wind over a finite fetch, Proc. Third U. S. Nat. Congr. Appl. Mech., June 1958; Amer. Soc. Mech. Engrs., 1958, 785–789.

When a turbulent wind blows across the surface of an inviscid liquid (water), waves are generated by the interaction of the convected fluctuations and the free surface. The rate of growth of each Fourier component of the wave field is the greatest when the convection velocity of the component of the pressure fluctuations is equal to the velocity of free surface waves of the same wave number. In this paper, the growth of waves over a finite fetch is studied, and an expression is derived for the mean square surface displacement $\overline{\xi^2}$ as a function of position in the wave field. For a semi-infinite sheet of water $\overline{\xi^2}$ is proportional to the fetch, a relation in good agreement with experimental observations.

From author's summary

5833. Vulis, L. A., Mixing gases by means of jets (in Russian), *Teploenergetika* **3**, 12, 37–41, Dec. 1956.

5834. Yudin, M. I., Changeability of meteorological elements in space and with time (in Russian), A. I. Voeikov and modern problems in climatology, Leningrad, Gidrometeoizdat, 1956, 175–192; *Ref. Zh. Mekh.* no. 4, 1958, Rev. 4298.

Paper is in the nature of a review. Attention given by A. I. Voeikov to the study of periodic and nonperiodic changes of meteorological elements is commented on. The basic work done by Soviet and foreign authors in the study of nonperiodical changes is enumerated; some of the most important results of these investigations are indicated and their value for the study of the problem of weather prognosis is emphasized. Next, the data are examined bearing on the spatial changeability of meteorological elements; data regarding the relation of the mean difference of pressure at two stations to the distance between the stations are concentrated into a relation of the evaluation of the influence of the direction of the line connecting the stations in question, such influence proving to be very substantial. In this connection, together with the usual correlational and structural functions, depending, generally speaking, on two arguments (the distance between the points of observation and the direction of the line joining these points), supplementary statistical characteristics are introduced (to wit, a correlational and structural function averaged in accordance with direction and dispersion of the mean value of the magnitude f on the circle of the given radius l, designated by the author as the overall correlational function of the magnitude f) already only depending on a single distance l. Some new data are furnished regarding the constitution of the field of humidity and of the fields of the geopotential at different altitudes in the atmosphere. Basic results are given regarding the linkage between the structural functions and the mean values of the derivatives of meteorological fields; a table is produced, bringing together the characteristic values of all the averaged first and second derivatives (spatial, time and mixed) of the basic meteorological fields in the 0 to 5-Km layer of the atmosphere. The dependence is noted of the order of magnitude of the averaged derivatives in relation to the scale of operations of the processes under investigation; this is also the subject of a specially designed table. To conclude, a series of magnitudes is given (the geostrophic vortex, the advection geostrophic change of vortex and temperature, etc.), a detailed scrutiny of whose changeability is demanded by the modern developments of dynamic meteorology and the methods of calculation of prognosis, which up to now have been carried out on an insufficient scale.

A. M. Yaglom

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

Naval Architecture and Marine Engineering

(See also Revs. 5453, 5500)

5835. Gerritsma, J., An experimental analysis of ship motions in longitudinal regular waves, *Inter. Shipbldg. Prog.* **5**, 52, 533–542, Dec. 1958.

Author tests the validity of linear superposition for an 8-ft ship model with block coefficient 0.60 in the following manner: (1) the model is forced to heave without pitching in still water, and the amplitude and phase of the motion and the driving force are measured; (2) the model is forced to pitch without heaving in still water and the amplitude and phase of the motion and the driving moment are measured; (3) the model is free to pitch and to heave in still water, and the amplitude and phase of the motion are measured; (4) the model is constrained to move without heaving and pitching in waves.

Four velocities of mean motion were tested (Froude number = 0.15, 0.20, 0.25, 0.30), and the analysis was interpreted in terms of coefficients of virtual mass, damping, cross-coupling, etc. The model was then placed in regular waves at the same Froude numbers, and the measurements were compared with the results of the linear superposition (as expressed by a pair of coupled differential equations). The agreement was satisfactory when coupling terms were included, but not when they were neglected.

F. Ursell, England

5836. Cartwright, D. E., On the vertical motions of a ship in sea waves, *Inter. Shipbldg. Prog.* **5**, 52, 554–565, Dec. 1958.

The vertical components of velocity and acceleration of any point of a rigid ship heading into sea waves are discussed in statistical terms. Heave, pitch and their time derivatives are assumed to be gaussian; the motion of the ship is assumed to be governed by an approximate linear theory. The distributions of several other statistical variates are deduced. Comparisons with measurements of waves and ship motions are given. Among other

results it is found that spectral distributions of vertical ship motions agree well with theory, but the relation of these with the sea waves is not so closely verified. F. Ursell, England

5837. Remez, Yu. R., Approximate equations for the periods of pitching and scending of a ship (in Russian), *Trudi Nikolaevsk. Korable-stroit. In-ta* no. 10, 45-48, 1957; *Ref. Zh. Mekh.* no. 2, 1958, Rev. 1937.

Based on certain assumptions concerning the hull form, approximate equations are presented for the periods of natural oscillation of a ship in pitching and scending, referred to the principal dimensions and coefficients of form of the submerged part of the hull. These formulas have been derived from the generalized expressions of the theory of linear pitching motion for the periods of oscillation of the ship with allowance for the resistance of the water. It is pointed out that the expressions given in the paper are sufficiently accurate for practical purposes: thus, for the ship "Dneproges," the error in calculating the pitching period by these formulas did not exceed 2%. A. A. Kostyukov

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

5838. Giers, I. V., The history of experimental ship-testing tanks (in Russian), *Sudostroyenie* no. 5, 20-25, 1957; *Ref. Zh. Mekh.* no. 2, 1958, Rev. 1946.

The dimensions, year and place of construction are given for the first experimental ship-testing tanks in the world, built in Britain and Italy. A brief history is given of the first experimental tank in Russia, built in 1891-1894 in St. Petersburg on the initiative of D. I. Mendeleyev. This tank had a length of 134 meters, breadth of 6.5 meters, and depth of 3 meters. The towing truck was operated through a steam engine of 20 hp by means of a winch installed at the head of the tank. The speed of the carriage was up to 3 m/sec. The activities of the tank during the first few years of its existence are described, in particular the researches of S. O. Makarov on the unsinkability of HMS "Victoria" and the rolling of the icebreaker "Yermak." D. A. Chumak

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

Book—5839. Pavlenko, V. G., Methods of calculation for the rolling of ships (in Russian), Leningrad, Sudpromgiz, 1956, 99 pp. + illus. 2r. 50k; *Ref. Zh. Mekh.* no. 3, 1958, Rev. 2954.

Chapter I. Analysis of existing methods of calculations for rolling ships in heavy seas. Para. 1. Review of existing methods of calculation for rolling. Para. 2. The trend of the latest investigation of rolling in heavy seas. Chapter II. Investigation of the free swinging of a ship when rolling without consideration of the forces of resistance. Para. 3. General remarks. Para. 4. Analysis of the basic properties of the swinging of a ship when rolling. Para. 5. The construction of frequency characteristics by the method of biharmonic approximation. Para. 6. Examples of the construction of a frequency characteristic. Para. 7. Analysis of forms of free swinging of a ship. Chapter III. Investigation of the free swinging of a ship when taking into account the forces of resistance. Para. 8. Setting up of the problem. Para. 9. Determination of the relation of the moment for the resistance forces to the angular velocity. Para. 10. Practical calculation of the moment for the resistance forces at large amplitudes. Para. 11. Influence of the forces of resistance on the frequency of the free swing of a ship when rolling. Chapter IV. Investigation of the rolling of a ship due to heavy seas. Para. 12. Setting up of the problem. Para. 13. The determination of the maximum amplitude of the rolling. Para. 14. Analysis of the forms of constrained rolling of a ship. Para. 15. Analysis of the properties of the phase angle. Para. 16. A numerical example of the determination of the maximum amplitude of roll of a ship in heavy seas. Para. 17. A numerical example for the drawing of an amplitude curve. Chapter V. Some supplementary questions relating to the theory of the rolling of ships in heavy seas. Para. 18. On the existence of two regimes of the rolling of a ship in heavy seas. Para. 19. On the maximum angular velocities and accelerations during rolling of a ship. Para. 20. On the influence of a connected moment for the water inertia on the maximum amplitude of the rolling. Keels fitted with fins and their influence on the rolling amplitude.

From author's summary

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

Friction, Lubrication and Wear

Book—5840. Bowden, F. P., and Tabor, D., Friction and lubrication of solids [Reibung und Schmierung fester Korper], 2nd ed., Berlin, Springer-Verlag, 1959, xi + 430 pp. DM 41.40.

This book is a translation into German of "The friction and lubrication of solids" by Bowden, F. P., and Tabor, D.; Oxford University Press, 2nd edition, 1954. The original manuscript was in English and the translation is accurate except for trivial deviations of meaning arising out of the substitution of the indicative for the subjunctive mood, for example. The translation is recommended to those who understand the German language better than English. L. V. Colwell, USA

5841. Radchik, A. S., and Radchik, V. S., On surface deformations in sliding friction, *Soviet Phys.-Doklady* **3,** 2, 418-420, Dec. 1958. (Translation of *Dokladi Akad. Nauk SSSR (N. S.)* **119,** 5, 933-935, Mar.-Apr. 1958 by Amer. Inst. Phys., Inc., New York, N. Y.)

5842. Miller, D. E., The measurement of dry sliding friction at elevated temperatures, ASME Ann. Meet., New York, N. Y., Nov./Dec. 1958. Pap. 58-A-225, 8 pp.

5843. Rettig, G. P., and Bekker, M. G., Obstacle performance of wheeled vehicles, Ordnance Corps, Land Locomotion Res. Branch, Res. & Develop. Div., OTAC Rep. 29, 88 pp., Mar. 1958.

On basis of static equilibrium equations and model tests on rigid-wheel vehicles negotiating hard surface of known friction coefficient with single idealized steps, author concludes obstacle performance of four- and six-wheel vehicles depends mainly on: (a) number of driven wheels; (b) ratio of wheel diameter to wheelbase; (c) longitudinal position of center of gravity; (d) suspension characteristics of six-wheel vehicles. Curves are given for prediction of obstacle performance. Author considers all wheels of four-wheel vehicles must be driven, and finds six-wheel vehicles have better obstacle performance than four-wheel vehicles.

T. K. Chaplin, England

5844. Lavik, M. T., High-temperature solid dry film lubricants, *WADC TR* 57-455 (PB 131 986; ASTIA AD 150 982), 20 pp., Feb. 1958.

Report covers the development and evaluation of a dry lubrication test machine and the testing of several dry film lubricants. In order to meet the very high temperature and pressure requirements currently placed on lubricants in the aircraft industry, it was necessary to devise a suitable test instrument. The first part of the program was spent in designing, constructing and calibrating such a device capable of testing dry film lubricants at pressures as high as 50,000 psi and at temperatures up to 800 F. Several minor revisions were made during the program leading up to the machine reported on.

Several commercial dry film lubricants and also some materials prepared in the laboratory were investigated for both friction coefficient and wear life at the various temperatures and pressures

available with the test machine. In general, the materials worked with, while effecting reasonable lubrication, did not exhibit the wear life which is desired. The lubricant properties of several materials are discussed, with the discussion serving mainly to point out areas in which further information is needed to realize the full benefits available from these materials.

From author's summary

5845. Zienkiewicz, O. C., A note on a new theory of hydrodynamic lubrication of parallel surface thrust bearings (in English), 9th Congrès Intern. Mécan. Appl., Univ. Bruxelles, 1957; **4**, 251–258.

Thermal wedge theory of parallel face bearings [cf Cope (AMR **3** (1950), Rev. 1810) and others] is extended to consider vertical temperature distribution in the film and type of viscosity variation. Basic equations are developed for two-dimensional motion and solution presented for one case: linear velocity variation as considered by Dizioglu (in "50 Jahre Grenzschichtforschung" 1955, 236–256]. From author's analysis, density variation is shown to account for only some 20% of pressures while viscosity effects account for the rest. Author promises a later more extensive paper showing the appreciable effect of the velocity distribution on temperature.

J. M. Robertson, USA

5846. Ozdas, M. N., The behaviour of the lubricating film in journal bearings (in English), 9th Congrès Intern. Mécan. Appl., Univ. Bruxelles, 1957; **4**, 259–271.

Journal bearing pressures increase and criterion of load per unit projected area is no longer acceptable. Designer needs to know local oil film temperatures and pressures. Theory assumes complete oil film.

Author investigates extent of oil film, using transparent bearing and fluorescent dye. Reviewer believes these are the first published results using sinusoidal loads. Results agree with those of previous investigators using steady loads. Considerable cavitation occurs in outlet film under all but lightest loads. With sinusoidal loads film could form and reform in loaded region of bearing. Load-bearing film moves intermittently within clearance space in direction of shaft rotation with frequency of load application.

Oil leakage is found to vary with ratio of load frequency to shaft rotation frequency. Minimum is at ratio of 0.5, which is also critical value for load bearing capacity.

Author states results are of a preliminary nature. Reviewer hopes this very useful work will be extended to include rotating loads and bearings of various length-to-diameter ratios.

W. A. Pullman, England

5847. Hackewitz, F. W. v., The influence of Kapitsa's viscosity on the hydrodynamic lubrication of a cylindrical roller bearing as affecting contact pressure and oil-film thickness, *J. Appl. Mech.* **25**, 4, 620–622, (Brief Notes), Dec. 1958.

5848. Hughes, W. F., and Osterle, F., Temperature effects in journal bearing lubrication, *ASLE Trans.* **1**, 1, 210–212, Apr. 1958.

Paper extends earlier analytical work [AMR **7** (1954) Rev. 3079; **8** (1955), Rev. 1232]. Authors consider all heat generated within fluid to be retained (adiabatic lower bound) and study partial journal bearing. Side leakage is not considered and density is assumed constant with internal energy dependent only on temperature. It is also considered that temperature and viscosity do not vary across the film. This assumption cannot be justified but is necessary to enable a tractable one-dimensional solution for pressure and temperature distribution. Lubricant flow rate is determined by Reynolds boundary condition.

Reviewer feels authors lost a good opportunity in not comparing their results with experimental findings. Without this, paper is of academic interest only. Clearly the real conditions are somewhere between the isothermal and adiabatic bounds. Reviewer notes that authors have now considered this fact [*Trans. ASME* **79**, p. 1225, 1957] in relation to hydrostatic thrust bearing. For such studies computer solutions, as outlined by Sternlicht and Maginniss [*Trans. ASME* **79**, p. 1483, 1957], appear superior.

R. A. A. Bryant, Australia

5849. Osterle, F., and Saibel, E., The effect of bearing deformation in slider-bearing lubrication, *ASLE Trans.* **1**, 1, 213–216, Apr. 1958.

It is mentioned by Michell [*Lubrication*, 1950] that in most cases discrepancies between experiment and established theory of slider-bearings are due to effects which arise from departures of the actual forms of the bearing surfaces from those considered in the theory. Object of present paper has been to cast light on the effect of elastic deformation. [See also AMR **11** (1958), Rev. 5262; *Trans. ASME* **79**, 2, 351–355, Feb. 1957].

It is considered that the slider is perfectly rigid and the bearing elastic. Film thickness is then no longer dependent on pressure (isothermal bound) alone. To formulate problem it is argued that the deformation will be small compared with film thickness and that the resultant effect on pressure and load capacity may be determined in the form of first-order corrections by setting up perturbation equations based on an inelastic solution. From equations so obtained, an IBM-650 was used to find dimensionless load capacity and film thickness corrections as function inlet/outlet (inelastic) film thickness ratio. Numerical example given indicated a decrease of 4% in inelastic load.

Reviewer notes caption under Fig. 5 should be *distance* and not *Film thickness ratio*. He agrees that paper does no more than contribute to an understanding of elasticity effects. It is apparent from the example given, in which the maximum film thickness correction is about 2 microns, that the real problem cannot be so conveniently divorced from surface roughness. At the same time the results may serve as a useful guide when the bearing metal is relatively elastic. A better physical picture of the influence of load and thermal distortion may be found in the paper of Baudry, Kuhn and Wise [*Trans. ASME* **80**, 4, 807–818, May 1958].

R. A. A. Bryant, Australia

5850. Russell, A. E., Some bearing tests made with a machine producing impulsive loading, Instn. Mech. Engrs., Prepr., 12 pp., Dec. 1958.

5851. Brandon, R. E., and Bahr, H. C., Load capacity tests on tapered-land and pivoted-shoe thrust bearings for large steam-turbine application, ASME Ann. Meet., New York, N. Y., Nov./Dec. 1958. Pap. 58-A-172, 6 pp.

Letter to the Editor

5852. Re: AMR **12** (July 1959), Rev. 3453: **Miles, J. W., On the disturbed motion of a plane vortex sheet,** *J. Fluid Mech.* **4**, 5, 538–552, Sept. 1958.

"A formal solution to the initial-value problem for a plane vortex sheet in an inviscid fluid is obtained by transform methods. The eigenvalue problem is investigated and the stability criterion determined. This criterion is found to be in agreement with that obtained previously by Landau (1944), Hatanaka (1949), and Pai (1954), *all of whom had included spurious eigenvalues in their analyses.* It is also established that supersonic disturbances may be unstable; *related investigations in hydrodynamic stability have conjectured on this possibility, but the vortex sheet appears to afford the first definite example.* Finally, an asymptotic approximation is developed for the displacement of a vortex sheet following a suddenly imposed, spatially periodic velocity."

Author's summary

Author believes that the phrases in italics, which were omitted by the reviewer, are of the essence. J. W. Miles, USA

Books Received for Review

ALPERIN, M., and GREGORY, H. F., editors, Vistas in astronautics, Vol. 2; Second Annual Astronautics Symposium, New York, Pergamon Press, Inc., 1959, x + 318 pp. $15.

ARMSTRONG, L. V., and HARTMAN, J. B., The diesel engine, its theory, basic design and economics, New York, The Macmillan Co., 1959, xviii + 360 pp. $8.75.

BAKKER, P. J., Porositeitsmetingen in een gefluidiseerd bed, Delft, Holland, Technological University, 1958, 178 pp. 24 cm (Paperbound).

BROOKS, H., General editor, Advances in semi-conductor science; Proceedings of the Third International Conference on Semi-Conductors, University of Rochester, August 18–22, 1958, New York, Pergamon Press, Inc., 1959, ix + 553 pp. $15.

ECKERT, E., Einfuhrung in den Warme-und Stoffaustausch, Berlin, Springer-Verlag, 1959, x + 295 pp. DM 28.80.

FRENCH, T. E., and VIERCK, C. J., Graphic science, New York, McGraw-Hill Book Co., Inc., 1958, vi + 758 pp. $8.50.

GREENE, E. F., and TOENNIES, J. P., Chemische Reaktionen in Stosswellen (Fortschritte der Physikalischen Chemie, Vol. 3), Darmstadt, Germany, Verlag Dr. Dietrich Steinkopff, 1959, xv + 202 pp. DM 25 (Paperbound).

HAYES, W. D., and PROBSTEIN, R. F., Hypersonic flow theory (Applied Mathematics and Mechanics, Vol. 5), New York, Academic Press, Inc., 1959, xiv + 464 pp. $11.50.

HOFF, N. J., editor, High temperature effects in aircraft structures (AGARDograph 28), New York, Pergamon Press, Inc., 1958, vii + 357 pp. $12.

LEFSCHETZ, S., edited by, Contributions to the theory of nonlinear oscillations, Vol. 4, Princeton, New Jersey, Princeton, University Press, 1958, v + 211 pp. $3.75 (Paperbound).

MATHESON, J. A. L., Hyperstatic structures; Vol. 1, An introduction to the theory of statically indeterminate structures (with chapters by N. W. Murray and R. K. Livesley), New York, Academic Press, Inc., 1959, xv + 474 pp. $15.50.

A phrase and sentence dictionary of spoken Russian, New York, Dover Publications, Inc., 1959, 573 pp. $2.75 (Paperbound).

PIPES, L. A., Applied mathematics for engineers and physicists, second edition, New York, McGraw-Hill Book Co., Inc., 1958, xi + 723 pp. $9.50.

POPOVICH, M., and HERING, C., Fuels and lubricants, New York, John Wiley & Sons, Inc., 1959, vi + 312 pp. $8.50.

PRIGOGINE, I., edited by, Advances in chemical physics, Vol. 2, New York, Interscience Publishers, Inc., 1959, ix + 412 pp. $11.50.

REICHENBACH, H., The philosophy of space and time, New York, Dover Publications, Inc., 1958, xvi + 295 pp. $2 (Paperbound).

RICHTER, W., Flugmechanik; Mathematisch-Naturwissenschaftliche Bibliothek, Vol. 25, Leipzig, B. G. Teubner Verlagsgesellschaft, 1959, vi + 296 pp. DM 15.60.

SMITH, G. W., and WOOD, R. C., Principles of analog computation, New York, McGraw-Hill Book Co., Inc., 1959, viii + 234 pp. $7.50.

STEBBING, L. SUSAN, Philosophy and the physicists, New York, Dover Publications, Inc., 1959, xvi + 295 pp. $1.65 (Paperbound).

SUDASCH, E., Schweisstechnik, Munchen, Carl Hanser Verlag, 1959, xiv + 798 pp. DM 65.

TRUITT, R. W., Hypersonic aerodynamics, New York, The Ronald Press Co., 1959, xii + 462 pp. $10.

WHITTAKER, SIR EDMUND, From Euclid to Eddington—A study of conceptions of the external world, New York, Dover Publications, Inc., 1959, ix + 212 pp. $1.35 (Paperbound).

WIENER, N., Nonlinear problems in random theory, New York, John Wiley & Sons, Inc., 1958, ix + 131 pp. $4.50.

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Tenth International

CONGRESS OF APPLIED MECHANICS

The **Tenth International Congress of Applied Mechanics** will be held in the Congress Building at Stresa (Italy) from **Wednesday, August 31 through Wednesday, September 7, 1960.**

Apart from a number of invited general lectures the technical sessions of the Congress will be held in two sections, viz.:

Section 1 Fluid dynamics (hydrodynamics and aerodynamics).

Section 2 Mechanics of solids (rigid body dynamics, vibrations, elasticity, plasticity and theory of structures).

It should be noted that thermodynamics and computational methods as such are not included, although specific applications of computational methods to pertinent problems of one of the two sections mentioned above are acceptable subjects for papers to be read at the Tenth Congress.

Previous Congresses have demonstrated the desirability of an adequate period of time for the presentation and discussion of individual papers. In order to allow a period of 45 minutes for each paper (30 mins. for presentation and 15 mins. for discussion) a Program Committee will make a selection from papers submitted for presentation. Abstracts of papers should be submitted *in four copies to the Secretary of the International Committee* (Prof. Mekelweg 2, Delft, Netherlands) *before January 1, 1960.* Preferably they should not exceed two typewritten pages (double-spaced) and in no case should they exceed four pages. In order to facilitate the work of the Program Committee it is recommended that abstracts be in *two* of the official Congress languages (English, French, German and Italian). Authors are urged to make their abstracts as clear as possible, since selection of papers has to be based upon them. *Decisions of the Program Committee are final,* and it will be understood that it is impossible to enter into correspondence about them with authors of papers. They will be informed promptly of the decision on each paper.

Day-to-day organization of the Congress is effected by the Italian Organizing Committee (President: Professor G. Colonnetti; Secretary: Dr. F. Rolla; address: *Consiglio Nazionale della Ricerche, Ufficio relazioni internazionali, Piazza della Scienza 7, Roma). All correspondence* (apart from submission of papers) *should be addressed to the Italian Organizing Committee.* Information on accommodations, also registration forms, will be obtainable from Dr. Rolla on and after September 1, 1959.

The Proceedings of the Congress will contain the invited general lectures at full length and abstracts of papers accepted for presentation in one of the sections. Authors are therefore permitted to submit their papers for publication in a scientific journal provided that such publication in journals should not occur before the presentation of the paper at the Congress.

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